ORIGINAL ARTICLE
DOI: https://doi.org/10.30932/1992-3252-2023-21-2-9

World of Transport and Transportation, 2023,
Vol. 21, Iss.5 (105), pp. 219–224

Alternativeness in the Architectural Design of Bridges and Overpasses

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ABSTRACT

Modern extensive foreign and domestic experience in design and construction of multifunctional overpasses and bridges indicates that they have become an integral part of urbanised systems. They are endowed with the functions of important urban objects, and with their appearance they have won the right to be considered iconic structures. The subject of the article refers to architectural design of bridges and overpasses. The authors set themselves the task of considering the aspects of combining the main functional characteristics with the aesthetic properties of the object, designating visual components of the project and the specifics of alternativeness of design.

The objective of the work is to consider alternativeness in architectural design of bridges and overpasses. A complex method, combining an analysis of the historical and modern experience of architectural theory and design practices, was based on technical literary materials. The study resulted in formulating indicators and leading principles of alternative design.

The use of alternatives in the process of designing urban bridges and overpasses allows not only to consider functionality and economic feasibility of a particular project and construction of an object, but also its architectural and artistic orientation, aesthetic component, as well as the designer's worldview and current trends in architecture. In the process of alternative design of bridges and overpasses, it is required to reproduce the overall complete image of the future structure, consider all kinds of details in structures and shape, and various criteria for layout and location in the environment.

Keywords: *alternativeness, architectural design, bridges, overpasses, criteria, ergonomics.*

For citation: *Odenbakh, I. A., Orekhov, S. A., Taurit, E. B. Alternativeness in the Architectural Design of Bridges and Overpasses. World of Transport and Transportation, 2023, Vol. 21, Iss. 2 (105), pp. 219–224. DOI: https://doi.org/10.30932/1992-3252-2023-21-2-9.*

The text of the article originally written in Russian is published in the first part of the issue.
Текст статьи на русском языке публикуется в первой части данного выпуска.

INTRODUCTION

The objective of the work is to consider alternative approaches regarding a few aspects of creation of the architecture of bridges, overpasses, since the alternativeness allows us to achieve organisation of the creative design stage, within which architectural standards are taken into account (for them, the critical component of the proposed methods leads to adequacy of the applied scenario, targeted object use). Trends in design of given buildings must comply with standards (including in the field of architecture). At the same time, the concept of alternative creation of structures (it provides for architectural transformations in the framework of evaluating various buildings) is based on finding a significant number of directed, often dissimilar factors in evaluation of the result. The problematic aspect of design of structures under consideration, to a greater extent than before, has attracted the attention of specialists in recent years.

From a given aspect, it is permissible to use a general *methodology* that involves the study of history, existing experience in the field of architectural theory, creation of projects based on information obtained from specialised literary sources. The architecture of transport objects accumulates quite significant experience that needs to be analysed and summarised. In many cities, one can observe an architectural component that is the most significant part of large-scale urban developments within the city. But the traditions of designing bridges in the Russian Federation (buildings of global significance were created) do not receive the required generalisation of theoretical aspects within the framework of a given specificity. One can recall only certain data considered within the framework of specialised courses or individual scientific works. They are dedicated to specific buildings, architectural projects. This information is mostly one-sided. It can be reduced to an analysis of exclusively road bridges, certain concepts of facade proportion, and component parts of buildings. It is necessary to highlight the change in the objects of work of architects which are buildings, structures.

Considering that the object of architecture should provide flexibility in accordance with the regulations, it is possible to obtain a general compliance of buildings with changing trends, the needs of various customers. As part of the transformation, the rules for creating a project are subject to change. Various new institutions are involved directly in the project. In this case, architects need to organise communication between different participants at the project development stage, to create a kind of «project culture».

RESULTS

The field of architecture, civil engineering and construction is today one of those areas in which there is a constant development of technology. This field attracted the attention of many domestic researchers [1–8] and foreign authors [9–13]. At the same time, construction of such objects as bridges, overpasses, as well as other objects related to the transport infrastructure belongs to the category of complex tasks. In this case, there is an increasing number of architectural projects for construction of such facilities, which, according to analysts, is a sustainable trend. At the same time, complexity of the designed objects is also increasing, which requires various alternative approaches to project development, as well as to construction itself.

Architecture is a field of human knowledge, due to which people today design and build buildings and structures. In addition, the concept of architecture also includes the buildings themselves and structures that form the spatial environment in which a person carries out his life activity.[1] With the help of architecture, an environment is formed that contributes to development of life and implementation of human activities based on his desires and aspirations, in accordance with the capabilities of technics and technology, as well as aesthetic perception. The ancient Roman architect Vitruvius summarised all this in his famous statement: «Architecture is strength, utility and beauty» [14].

The road environment, in addition to roads, includes additional objects in the form of bridges and overpasses, which are a group of mandatory functional objects of the road environment. These structures are man-made and have several distinctive features and characteristics, which include construction, materials, location, as well as the purpose of objects. The design of bridges and overpasses, from the point of view of architecture, involves combination of the main functional characteristics, as well as the aesthetic properties of the object, which are in close interaction with each other. Materials and structures used in construction of bridges and overpasses should not only determine the functional properties of the object, but should also have a certain appearance that fits organically into the environment and is aesthetically pleasing. In addition, the choice of the bridge or

[1] Big Encyclopedic Dictionary. Ed. A. M. Prokhorov. 2nd ed., rev. and enl. Moscow, Great Russian Encyclopedia, 2000, 1456 p.: ill. ISBN 5-85270-160-2; ISBN 5-7711-0004-8.

overpass design itself, as well as the materials that will be used for its construction, depends on where the object is located.

Particular attention should be paid to the traditions and cultural characteristics of the territory where the objects of the road environment will be located. The appearance of both the entire bridge or overpass, as well as its individual elements, must comply with certain criteria for landscape architectural design, especially in terms of building approaches to the facility or when choosing a traffic interchange scheme. An important role in the process of designing an artificial structure is played by the architectural composition, due to which such parameters as scale, rhythm, symmetry, proportions, and architectonics are assessed. At the same time, the design process makes it possible to combine various architectural, monumental, and decorative elements of art.

Architectural design is carried out in accordance with the design and estimate documentation, the requirements for which are fixed in SNiP and TKP [construction norms and rules; technical code of existing practices], which determine, among other things, the number of stages of construction of facilities. Designing, in addition to direct development of the object plan and construction stages, involves justification of investments involved in implementation of the presented project.

One of the requirements for construction of bridges and overpasses is the visual component of the project, which allows you to assess how organically the future object fits into the environment. This is especially true for bridges and overpasses located in urban areas [15]. Today, much attention is paid to assessment of the aesthetic state of a building object. Even though Russian engineers, designers and architects today are showing increasing interest in design of urban bridges and overpasses, the main focus is on the functional characteristics of these structures, while the aesthetic component does not receive due attention [16].

According to foreign and domestic studies, one of the most effective ways to make an optimal decision is variant design, which results in creation of an object that meets social, cultural, historical, as well as city-forming criteria and requirements. Variant design is a process in which designers optimise the developed tasks by evaluating the level of perspective of the model and forms in terms of their compliance with architectural requirements. Work based on the variant method is implemented in several stages and depends on the goal. The preliminary solution, formed based on the variant design, has a free style, however, it is required to offer such options that will be adequate, as well as have differences. Thus, variant design involves identification of such projects that have novelty, as well as aesthetics in the context of construction of the road environment.[2]

The search for alternatives is a creative and cognitive process that allows you to evaluate the novelty and quality of the proposed options.

The goal of real design is to establish such an alternative, which does not have internal contradictions, and which has all the necessary properties and qualities, both functional and aesthetic, that meet the requirements for a bridge or overpass.

Alternative design means what technology can be used in a situation where there are many tasks, as well as options for solving these problems. Therefore, development of certain criteria and guidelines is required, according to which alternatives can be evaluated. As an alternative, a project is considered, which is a target set of characteristics and properties that can be implemented and achieved through certain activities. The basis for determining the criteria and guidelines, as well as the conditions for implementation of activities are the standards of project activities, development of project documentation, as well as key theoretical and philosophical foundations.

The functions that are performed by the principles of alternative design include: a function that forms a certain worldview of a designer, his individual style and approach to design, including at the value level, as well as the function of forming a theoretical basis for creating alternative design technologies. The leading principles of alternative design are:

1. The principle of "critical modification threshold" implies establishment of clear boundaries, as well as project management methods that will allow adjustments to be made, as well as to assess the social consequences of the changes being made. The architectural environment in this case is presented as self-organising, for which the architecture is the main and universal element, and which does not require strict control from the outside.

2. The principle of personification of the process and results of socio-cultural design includes several characteristic features:

• Ideas and projects, based on which alternatives can be formed, contribute to creation of such conditions in which human self-

[2] Pastushkov, G.P., Rasinskaya, L. G. Design of bridges: a manual for students of the specialty 1–70 03 02 "Bridges, transport tunnels and subways": in 2 parts. P. 1. Minsk, MNTU publ., 2017, 41 p.

realisation is possible through architectural activity, implemented through manifestation of human creative activity.

• Relationship between the personality of the creator of the project and the architectural processes that actualise the moral attitudes formed in the context of the historical process.

• The idea of architecture as a of spiritual component of human life, including various values, meanings, images, etc.

3. The principle of optimal orientation, which contributes to preservation and change in the ratio of traditional and innovative mechanisms and processes of cultural dynamics. In matters of a balanced presentation of traditional and innovative forms of architectural activity, leading at this stage, there is a traditional trend. This principle is implemented based on the following circumstances:

• Preservation and transformation are key elements that determine the direction of development of the cultural system.

• Predominance of traditional forms and the focus on their preservation and reproduction is determined by the specific nature of Russian architecture.

The process of designing bridges and overpasses includes one or two stages; however, development of any project of such a structure involves development of alternatives, as a result of which the most optimal solution is selected in accordance with such indicators as technical and economic characteristics, the use of innovation in production, the use of local or rationally selected materials, construction time, project payback period, operating costs.

The most common approach to construction of bridges and overpasses in Russia is considered to be the method of technical feasibility and economic or operational benefits, based on implementation of specific indicators declared during planning and design. At the same time, the aesthetic component is often not considered properly, while evaluation of the aesthetic indicators of bridges and overpasses includes assessment of conformity of the shape of the structure with the environment, as well as overall harmonious appearance of the structure.

The formation of the aesthetic component of a bridge or overpass is a creative task, the solution of which involves considering various requirements for urban structures. In particular, an important characteristic of the shape of such structures is the span length, as well as the span types of structures and supports, etc. The designer's job is to form several alternative options that are developed based on assessment of the area, as well as the professional experience of the designer. Next, the technical and economic indicators of each design option are evaluated, after which one of the most competitive ones is determined. The alternativeness is evaluated based on the following indicators:

• The principle of eventuality, according to which the choice of the appearance of the structure is determined by the preferences of the architect.

• The principle of development indicates formation of the appearance of the structure based on the creative direction of the author.

• The principle of multivariance assumes the dynamic nature of the search for options for the appearance of a bridge or overpass.

• The principle of orientation or direction implies the use of the original image to form alternative options.

• The principle of comparison justifies consideration of many different and hidden features when looking for an option.

• The principle of "ideality" establishes the requirement for the maximum proximity of the alternative to the ideal image.

• The principle of limitedness determines the absence of contradictions between the proposed option and the conditions and terrain for construction of the facility.

DISCUSSION

The alternative design process involves reproduction of a general complete image of the future structure, considering all possible details in structures and form, as well as various criteria for layout and location within the environment. In addition, it is important to necessarily consider the city-forming functions of the proposed project, assuming that the bridge or overpass is an important element of the urban or road environment. Thus, the use of alternatives in the process of designing urban bridges and overpasses allows not only to consider functionality and economic feasibility of a particular project and construction of an object, but also its architectural and artistic orientation, aesthetic component, as well as the worldview of the designer and modern trends in the field of architecture.

The principle of multivariance suggests that in the process of designing a bridge or overpass, it is necessary to consider several options to shape external appearance of the structure to choose the most optimal one. To put this principle into practice, the following steps can be recommended:

Definition of requirements. It is necessary to determine design requirements, such as load capacity, spans, dimensions, angle of inclination, etc. These requirements are the basis for

developing options for external appearance of a bridge or overpass.

Creation of a basic design that will be used as a starting point for creating other designs. The basic design should meet the requirements and represent an overall concept that can be expanded and improved.

Development of several options. It is necessary to develop several options for external appearance of a bridge or overpass, considering the requirements and the basic design. Options may differ in shape, materials, colour, and other parameters.

Evaluation of each option. Each option must be evaluated in terms of suitability, aesthetic appeal, technical feasibility, cost, and other parameters. It is important to consider all aspects of the design to choose the best option.

Comparison and selection of the optimal option. Based on assessment of each option, it is necessary to compare and select the most optimal one. The optimal option must meet the requirements and represent the best combination of aesthetic appeal, technical feasibility, and cost.

Refinement and improvement. After choosing the optimal option, it is necessary to carry out additional work to clarify and improve it. The selected optimal option must meet all requirements and be the best solution considering all parameters. This means that the chosen design must be aesthetically pleasing and functional, provide the required technical performance, meet climate and environmental requirements, and be cost-effective.

It is also important to make sure that the chosen option can be successfully implemented and will not lead to undesirable consequences in the future. To do this, it is necessary to conduct a thorough analysis of all parameters and consider all possible factors that may affect the selected design.

If the selected option does not satisfy all the requirements, then additional work may be required to clarify and improve it. In this case, it is necessary to return to the options development process and consider other alternatives, considering the identified shortcomings and problems.

Overall, choosing the best solution for a bridge or overpass requires careful analysis and consideration of many factors. The principle of multiple options will help choosing the most optimal option, considering all the parameters and requirements, and ensure successful implementation of the project.

The principle of *randomness* and the *principle of development* are different approaches to the design of architectural structures.

The randomness principle suggests that the design process of an architectural structure may include random elements. For example, an architect might choose the shape or colour of a structure based on a randomly selected number, or randomly select materials for a structure. This principle can be useful for creating original and unusual solutions that can attract attention and arouse the interest of viewers.

The development principle, on the other hand, suggests that the process of designing an architectural structure should be based on creative development and ideological growth of the concept. The architect starts with a small number of ideas and gradually develops them, refines them, and complements them until he reaches the optimal result. This principle can lead to designs that well reflect the individuality and creative direction of the author.

Thus, the principle of randomness and the principle of development represent different approaches to design of architectural structures. When choosing one of these principles, the characteristics of a particular project and the personal preferences of the architect should be considered.

BRIEF CONCLUSIONS

The approaches proposed in the article to the use of alternatives in the process of designing city bridges and overpasses in general make it possible to take into account the functionality and economic feasibility of a specific project and construction of an object, as well as its architectural and artistic orientation, aesthetic component, as well as the creative view of the designer and modern trends in the field of architecture.

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Article received 05.05.2022, revised 12.05.2023, approved 18.05.2023, accepted 19.05.2023.

Editorial note. *It would be advisable to consider this article as a primary initiative to discuss the topic raised, the beginning of a deeper discussion on the place of alternative design from the point of view of additional criteria of aesthetic value, compliance with the urban landscape in transport, primarily urban construction.*

We can agree with the opinion of one of the reviewers that if the general foundations of alternatives in the design of transport facilities are laid during training of students in such specialties as bridges and structures, and the need for alternative approaches does not give rise to debate, then the goal of research beyond the general methodological principles and criteria outlined in the article should be development of practical recommendations for assessing the architectural parameters of a structure, that is, its composition. Many unresolved questions arise regarding a more strict definition of terms and their practical implementation, for example, the principle of multivariance, which assumes the dynamic nature of the search for options for the external appearance of a bridge or overpass, and many others.

We must not forget about the special importance of high requirements for strength and other characteristics of transport facilities outlined by the authors as well, and the need to comply with all prescribed standards, which requires a special approach to combination of technical, technological, and architectural solutions. The financial and resource aspects, also mentioned by the authors, require significant elaboration as well; we are talking not only about a potential increase in cost, but also about the procedure for drawing up regulatory documentation, including documentation regarding competitive undertaking, considering aesthetic and urban aspects when organising design and construction.

The theoretical and methodological approaches stated in the article require significant specification, and in this regard, the publication may serve as a starting point for transition of the discussion of this topic into a practical plane.