

Nina Kazhar

## EVOLUTION OF STYLES IN ARCHITECTURE OF BRIDGES

### Introduction

Bridge - one of the most ancient fortifications, which serve to ferry communications and water supply systems over various territorial barriers. At the same time the bridge is an engineering and architectural object and an important part of the landscape environment, reflecting the technical, functional and aesthetic categories of time and place of its erection. Bridges in Rome and Venice, Dresden and London, Vienna and Warsaw play an important role in the formation of the ensemble of the urban environment and represent a significant historical value. The article is devoted to identifying patterns of architectural and constructive formation and development trends of architecture bridges in the context of changing architectural styles.

### 1. Architecture of bridges of oriental satrapies and antique

The first in the history of mankind bridges were tree trunks thrown from one bank to another, sometimes stacked on flat stones. Foundation of the bridges consisted from natural elements, which often and today are used as supports (Fig. 1).



Fig. 1. Natural bridge foundation

On the construction of bridges in Ancient Egypt is known from the reliefs of the New Kingdom (sixteenth and eleventh centuries. BC) and from the descriptions of Herodotus. Their design was based on two main systems of proportions calculation: a modular (use of a certain size unit-modulus) and geometric (in which all three projections of the structures are defined by geometric constructions based on the square or circle). Occasionally the rules of calculating the "golden section" were used.

Wooden and stone bridges were built in Mesopotamia. King Nebuchadnezzar II described the "powerful water" of the Euphrates River in Babylon (VI cent. BC), through which a bridge with the length of about 300 m was built. Its construction consists of 7 spans which stand on brick bases, covered by stone (Fig. 2). Each span was 9 m length.



Fig. 2. The bridge over the Euphrates River in Babylon

Bridges of Ancient Greece didn't constitute significant buildings due to lack of large rivers in a mountainous region. Usually, their design is flat stone slabs or false arches (Fig. 3). By moving the army of Alexander the Great wooden and floating bridges are often erected. Significant progress in the development of architecture of bridges has been made in ancient Rome. During this period, there was the first theoretical work on their construction. In book VII of the treatise of Vitruvius' "10 books on architecture" (I cent. BC) contained information on the construction of aqueducts, were given information about the properties of water, calculations and drawings of necessary arrangements are given. Roman Bridges II-I cent. BC tended to have a symmetry axis of the central arch. We can distinguish two compositional methods: the increased passage of a small bridge arches (Fig. 4) and the use of multiple spans with a larger width of the river bed (Fig. 5). By the end of the bridge span arches in this case decreased.



Fig. 3. Bridge in the Greek city

Building of the first aqueducts was in the period of the Roman Empire. Underground water pipes were used previously in the ancient East and in Greece. However, the water channels made of concrete and stone, raised above the ground on arcades, was typical only for ancient Rome.



Fig. 4. The bridge across the Tiber in Rome (I cent. BC) - example of great span construction

Romans were the first who used the type of gravitational plumbing with the free mirror of water flow, enclosed in large channels of rectangular cross section, topped with a flat or arched stone slab. Each aqueduct consisted of system of water diversion, channel on which water was supplied from the source to the city, tanks and distribution systems.



Fig. 5. The bridge across the Tiber in Rome - the type of construction multispan

On the trail of aqueducts in the places of egress of underground canals bridges were built. The design of the aboveground part of the channel depended on the terrain. In the first case, channels were placed on a solid wall at the exit from the ground. The second type is a channel, put on a low arcade heels arches which lie directly on the foundation. The third option was to placement the channel on the arches of medium height. The most common is taking styling channels at high arcade. At the intersection of roads special arch were used.

The most important principle of aqueduct solution was extremely clear expression of it's construction. Relations between the basic elements of design and parts were defined by the rule of "golden section", which gave them the harmony (Fig. 6).

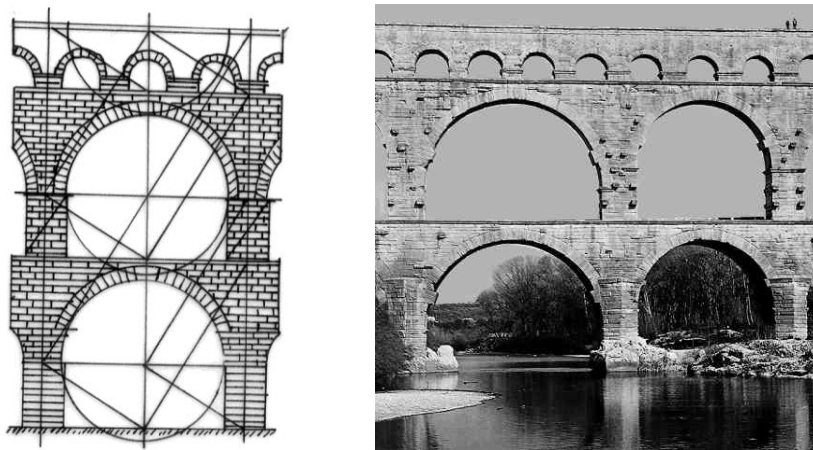


Fig. 6. Roman aqueduct construction



Type tiered long-span arcade is Gard aqueduct, constructed in the I-II cent. in southern France in Nemausus (Nîmes). Its main art features are horizontal orientation, scale, the dynamic rhythm of the arches, complex method of proportioning (Fig. 7).



Fig. 7. Gard aqueduct in Nîmes (Nemausus)

On the territory of modern Spain has developed a peculiar type of composition of a Roman aqueduct, which differs lighter division. Vertical supports are the full height of buildings (Fig. 8). Aqueducts, which preserved the ancient features, were built in the Byzantine Empire (Justinian and Valens aqueducts in Constantinople).



Fig. 8. Aqueduct at Segovia

## 2. Architecture of bridges of the middle ages

The earliest surviving medieval bridges in Western Europe were built in the XII century and have pronounced features of the Romanesque style. The features of their design and architectural decisions were influenced by social and political rela-

tions that existed and a constant military threat. By the same functions to connect two sides of the river or ravine was added defensive role to protect the borders of the city or castle. Therefore, bridges are often turned into a kind of fortress with gates and defensive towers with loopholes (Fig. 9). Castles, surrounded by a moat, at the entrance fitted with wooden drawbridge.



Fig. 9. Medieval Bridge

Bridges not only performs communication functions. In the cities of England and France in the XII-XIII centuries built bridges-markets (Notre Dame and O-Shanzh in Paris) and Bridges-streets (Bridge in London). For example, on the bridge in London located houses with shops at ground floor, there was a small church and a mill (Fig. 10).



Fig. 10. Bridge-street in London (1176-1209)

In XIII-XIV centuries in the architectural solution of bridges have been changes associated with the development of a new architectural style - the Gothic. Functionally significant changes have not occurred. Still a big part of the bridges of Paris is a type of bridges-markets, built with stone buildings. An example of bridge-street is the Charles Bridge in Prague (1352) (Fig. 11). At the entrance to the bridge were located Gothic towers with arched gates, decorated with stone sculptures and carved decoration. Its 16 stone spans had semi-circular shape and based on the feet of various thicknesses ( $7\div 11$  m).

Gothic bridges are usually completed and updated for many years. Changes in functional and economic demands made of construction craftsmen to improve the skills and building techniques.

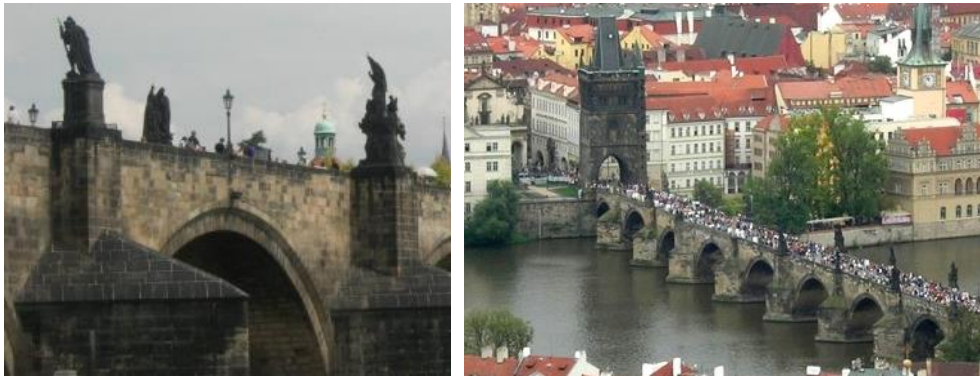


Fig. 11. Charles Bridge in Prague (start construction in 1352)

In XIII-XIV centuries bridges are diverse forms of spans. Constructions made by the Roman samples were semicircular arches. Use of the Gothic lancet arches increases the height of the bridge, complicated construction and increased construction costs. Composition Gothic bridge was beautiful: steep congresses, broken plan, the presence of the towers, arched spans a variety of forms (Fig. 12).



Fig. 12. Bridge Towers at Strasbourg



In the late Gothic period, there has been striving to reduce decorative items made for the cost of building materials (which was due to difficulties in transporting them). Bridges, built by non-professional builders, often had a number of kinks in the plan and consists of roughly hewn stones without static design features (Fig. 13).



Fig. 13. Example of rough masonry Gothic Bridge

### 3. Architecture of renaissance bridges

In the XIV century in Italy (in the XV century in other European countries) began to use new techniques to build bridges, typical of the Renaissance. The presence in the Italian cities a large number of architectural monuments of ancient Rome contributed to the creative use of techniques of ancient masters. Formed new styles, such as in Venice there was the type of "Brokeback" footbridge, made of stone or marble, with the canvas in the form of stairs. Preserved the functions of medieval bridges, in particular bridges-markets have been built in Italian cities where trade flourished. The most famous examples of this type of bridges are the Rialto Bridge on the Grand Canal in Venice (1588-1592), which has a gallery with three passages, and the Ponte Vecchio in Florence (Fig. 14). Houses were built on many of the bridges of Paris, including built in 1507 the bridge of Notre Dame.



Fig. 14. Bridges - shopping streets: on the left - the Rialto Bridge in Venice, on the right - the Ponte Vecchio in Florence



In the Renaissance were written the first theoretical works on the construction of bridges. Among them are works by L.B. Alberti's "Ten Books on Architecture" (Book XVIII, 1485), A. Palladio "The Four Books on Architecture" (1570) (Fig. 15), treatises B. Amante et al.



Fig. 15. Bridge A. Palladio

#### 4. Architecture of bridges in styles of baroque, classicism and eclecticism

Venetian Bridge of Sighs (1605) reflected the changes in the shaping of bridges associated with the development of the Baroque style (Fig. 16). The elliptical shape of the arch, arc door with profiled archivolt and volutes, decor in the form of reliefs, mascarons and cartridges are typical of Baroque architecture. During this period the old bridges were adorned with sculpture, for example, the bridge Sant'Angelo in Rome (Fig. 17).

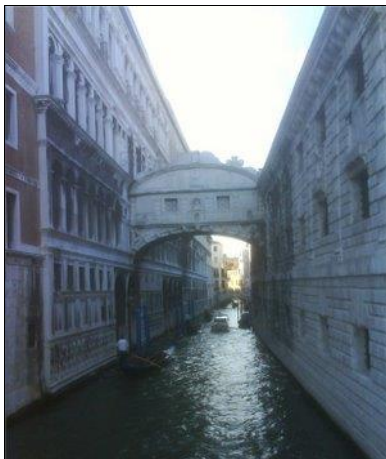


Fig. 16. Bridge of Sighs in Venice



Fig. 17. Sculptures on Sant'Angelo Bridge in Rome

In the XVII century large bridges were built in France. New look had the Pont-Neuf Bridge in Paris, which was built in years 1578-1604. It connected the banks of the Seine near the Cité island. It had no buildings in its design, allowing pedestrians to see the river and its banks. Later, the island was connected with the banks by three pairs of new bridges.

An important contribution to development of bridge building in the period of French classicism have graduates of the Royal Academy of Architecture in Paris and founded in 1716 Corps of engineers of bridges and roads. Their projects were characterized by the symmetry of the arch span, classic proportions and decor. An example of classicism in the XVIII century was the Concorde Bridge.

At the turn of XVIII-XIX century's eclectic artistic techniques reflects in the architecture of bridges. The period of Historicism was characterized by conscious use of decorative elements of historic styles. In contrast to the pre-Romantic era, the external decoration was used as "clothing" without connection to functional or structural solution structures. Bridges appeared in styles of neo-classical, Gothic, baroque, "Egyptian style" etc.



Fig. 18. Chain Bridge in Budapest

Classic techniques of shaping and decoration was used for solving the artistic appearance of Chain Bridge in Budapest (Fig. 18), Alexander III Bridge in Paris (Fig. 19) and others.



Fig. 19. Alexander III Bridge in Paris

Receptions imitation of medieval buildings were especially prevalent in England (the Tower Bridge in London) and Germany (the bridges in Hamburg, Hannover, Bonn, etc.) (Figs. 20, 21).

XIX century characterized by rapid development of industries that require a new road network and, accordingly, the construction of a large number of bridges. Architects and engineers have sought for the diversity of composite devices, the choice of new scope and the silhouettes of bridges.

This problem led to the need for the use of modern materials: metal and concrete. Often in place of the old bridge the new one was built using new advances in technology and materials (Fig. 21).



Fig. 20. Tower Bridge in London (1886-1894)



Fig. 21. Bridge in Bonn. The combination of metal structures and medieval decor



Since the second half of the nineteenth century for the construction of bridges has been increasingly used in metal structures. Fast-paced rail demanded construction of the bridge type, which has openings in the form of metal trusses with parallel zones.

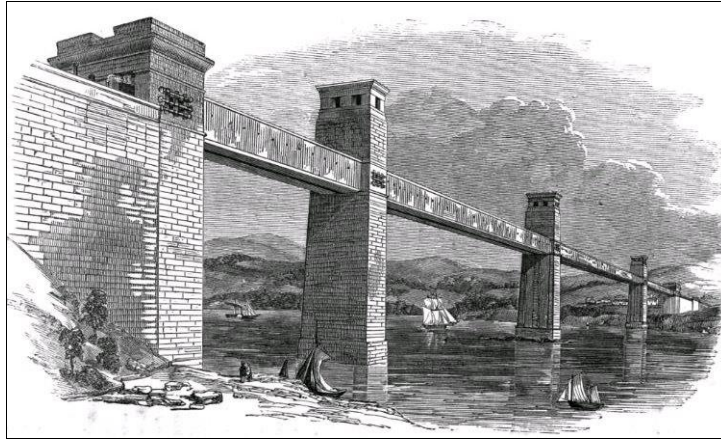


Fig. 22. Old and new Britannia Bridge

Before the engineers faced the task of creating types of long-span structures, require complex engineering calculations. A new stage in the history of bridge construction started. Its study is an independent task which beyond the scope of this article.

## Conclusion

Performed an analytical summary of trends in the development of bridges showed changes in architecture, morphogenesis and constructive role of styles in the creation of the architectural image of transport constructions with high functional, technological and aesthetic qualities. Features of building bridges all over

the historical period studied were associated with the development of construction equipment and state of scientific knowledge on structural analysis. Architecture bridges was caused also by the type of the materials, design techniques and technology of construction, physical facilities of a particular society.

Despite the fact that the main features of the architectural appearance of the bridge are primarily dependent on these factors, they were exposed to the direct influence of the prevailing architectural style and individual creative manner of the author. Study the use of facilities of three-dimensional composition, the relationship of structures and materials with architectural form showed that the treatment facilities of bridges, not only engineering but also of architectural activity, allowed for centuries to develop a kind of aesthetics of this buildings in line with the overall style of European architecture.

## References

- [1] Пунин А.Л., Архитектура современных зарубежных мостов, Стройиздат, Л.: 1974, 168 с.
- [2] Всеобщая история архитектуры. В 10-ти т.: Изд-во лит. по строит, М.: 1970-1973.
- [3] Camberlin W., History of preservation practices for highway bridges, NCHRP Symp. 1999. Nb 275, p. 1-58.
- [4] [www.images.pl](http://www.images.pl)

## Abstract

The development of architecture of bridges in conformity with change of architecturally-art styles is show in this paper. A brief analytical overview of the history of bridges building is made, methods for constructing three-dimensional composition are considered, the interrelation of constructions and materials with the architectural form of bridges is shown.

## Ewolucja stylów w architekturze mostów

### Streszczenie

W artykule przedstawiono etapy rozwoju architektury mostów od czasów starożytnych do początku XX wieku zgodnie ze zmianą stylów architektonicznych. Dokonano krótkiego analitycznego przeglądu historii budowy mostów, przeanalizowano metody kształtowania trójwymiarowej i przestrzennej kompozycji, pokazano związek konstrukcji i materiałów z formą architektoniczną mostów.