

ARCH BRIDGES MADE BY CROATIAN BUILDER

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Abstract. *Milivoj Frkovic (1887.-1946.), very creative Croatian bridge builder, was acting in the first half of the 20.th century. Frković started his work in the era of truss steel bridges. The massive usage of such structures, influenced by steel industry, for both railroad and road bridges, was widespread throughout the country. Such practice required neither creativity nor much knowledge. Frkovic opposed this plague of ugly bridges by designing original structures made of stone, concrete and masonry. He showed that it was possible to build unique, beautiful, more functional, different bridges, which were price competitive but superior in all other aspects. Milivoj Frkovic designed and mostly constructed a number of bridges. Some of them are briefly presented in the paper.*

1 INTRODUCTION

Many remarkable bridges have been built in Croatia throughout the history. Some of them date from antique times, such as aqueducts built for the roman emperor Diocletian for his palace near the town of Split. They were followed by medieval achievements such as Dubrovnik city bridges, and Tounj bridge in two levels. Among the new era achievements there is the largest reinforced – concrete arch, bridge between the mainland and the Krk island¹.

There were built as a consequence of important European traffic routes, both historical and contemporary, passing through Croatia from East to the West and from the South to the North. These routes cross large rivers, such as Danube, Save and Drava and mountain systems (Dinarides). Also, there are several crossings between mainland and some of islands on the Adriatic Sea.

In these circumstances it was natural that some important builders worked there, such were ancient roman builder Apolodoros of Damascus, XVI Century Turkish builders Kodža mimar Sinan, mimar Hajrudin and others. Extraordinary scientific contributions of Croatian great minds should also be mentioned: Faust Vrančić gave the first concept of the cable-stayed bridge, while Ruđer Bošković made stational calculation for the dome of St. Peters cathedral in Rome. But, for most buildings the name of the builder was not preserved².

Milivoj Frković worked in Croatia in the first half of 20th century as a very successful builder of mostly arch bridges of natural and artificial stone. His accomplishments will be briefly described in this article.

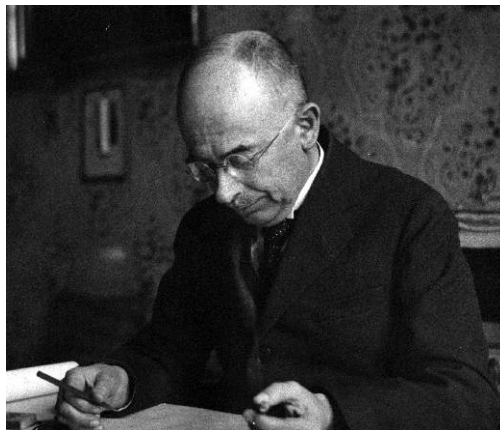


Figure 1. Constructor Milivoj Frković (1887-1946)

2 SOME BIOGRAPHICAL FACTS

Milivoj Frković was born in Petrinja in 1887, and graduated at the Technical College in Vienna, Austria. He spent in public service almost all of his professional career, as a technical consultant of the Sava County.

Frković started his work in an era of a truss steel bridges with roadway at the lower level.

Massive usage of such structures, influenced by the steel industry, for both railroad and road bridges was widespread all over the country. Such practice did not require neither creativity nor much knowledge from the engineers, as it was quite standardized and industrialized, but the results were not great either. Frković opposed this plague of ugly bridges by designing original structures made of stone, but also of steel, concrete, masonry ... thus showing that in contrast to the industrialized routine of repeated standardized bridges it was possible to build unique, beautiful, more functional, different bridges, price competitive but superior in all other aspects³.

Load – bearing systems of most of his bridges are stone arches. His approach to appearance and detail design was very thoughtful and with much of the constructors and artistic enthusiasm. This is the main reason that most of his bridges are masterpieces both from the structural and from the aesthetical point of view.



Figure 2. Lika Bridge in Kosinj – a supreme example of excellent aesthetics (author: Frković).

As this was usual practice at his time, Milivoj Frković was the builder in full sense of the word – first he designed his bridges, and then managed their construction as well.

He died in Zagreb in 1946.

3 ARCH BRIDGES DESIGNED BY MILIVOJ FRKOVIĆ

3.1 Masonry bridges

In north parts of Croatia little quality natural construction stone or quarries can be found, but on the other hand the masonry industry is rather developed. This is the reason why in this region Frković built mostly brick bridges. The most interesting among them is the bridge in Sisak.

The bridge over Kupa River in Sisak was constructed from 1927 to 1934 and comprises three elegant arches over the river and three more over the riverbanks. It presents almost unattainable harmony achieved by a combination of brick and natural stone and a number of superiorly designed and constructed details of cornices, railing, archvaults, spandrel walls, pillars, etc. The bridge survived all the wars, succesfully carried all loading and is still today in everyday use as one of the most valuable bridges of its style⁴.



Figure 3. Kupa Bridge (Sisak) constructed by Frković.

Elliptical arches of this bridge were constructed of bricks, with archivolts made of natural white stone, while brown-red bricks were used for spandrel walls and railings. Details are shown on the original drawing (figure 4).

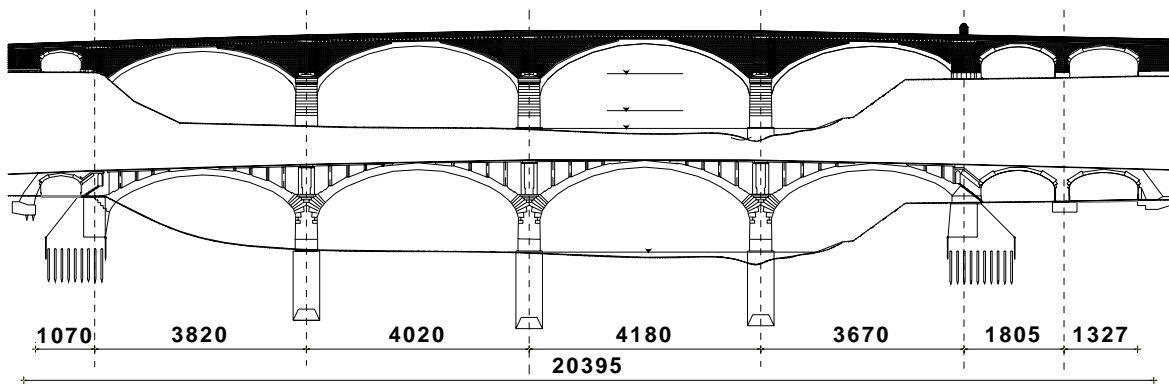


Figure 4. Layout of the Kupa Bridge in Sisak.

Another interesting masonry bridge made by Frković is the one across the river Vuka in Ernestinovo. It was constructed with five vaults of segmental form each spanning 8m and spandrel walls rising into very massive railings. The emphasized is made on vault edges which are moved inside in regard to the spandrel walls above them. Column tops are emphasized as well, using white stone.

There are some other masonry bridges worth mentioning, such as Biđ in Velika Kopanica, over the bay near Gramačnik, Zoljanke near Našice, Kutinica in Kutina, Čađavica in Sladojevci, Krajina in Čačinci⁵.



Figure 5. Vuka river bridge in Ernestinovo.

3.2 Bridges made of natural stone

In the central and south parts of Croatia, rich with quality natural construction stone and a long tradition of its exploitation, Frković built stone bridges. Here are some examples.

The bridge over Lika River in Kosinj is one of the aesthetically most successful bridges in Croatia. It bridges the river with three harmonious arches 18 m in span with circular openings over the pillars. Together with the stone edging and protrusions of distinctive bridge lines they fit superbly producing a unique image. Bridge was built in 1935. It was damaged during the II World war, but was rebuilt in its original form.

The bridge across the river Bogdanica in Gospić was built in 1932 (figure 6). It comprises three stone arches, similarly to the one across Dubračina in Crikvenica built in 1938 (figure 7).

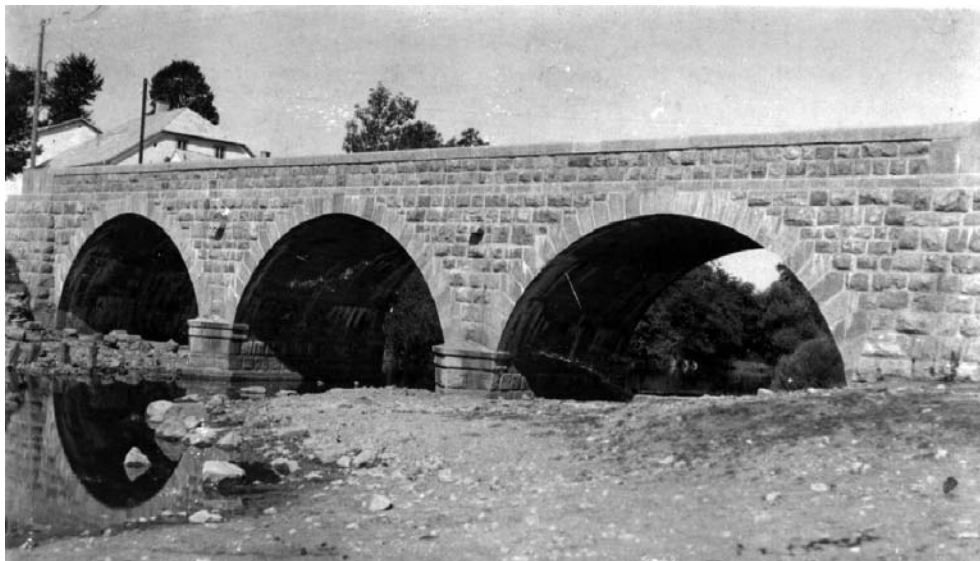


Figure 6. Bogdanica river bridge in Gospić.



Figure 7. Dubračina bridge in Crikvenica.

In the same year Frković built stone bridge with two vaults (figure 8) very close to the sea in Novi Vinodolski. As a part of the national park Plitvica lakes Frković built a non invasive stone vault which has perfectly blended into the ambient of the Korana river waterfalls (figure 9).

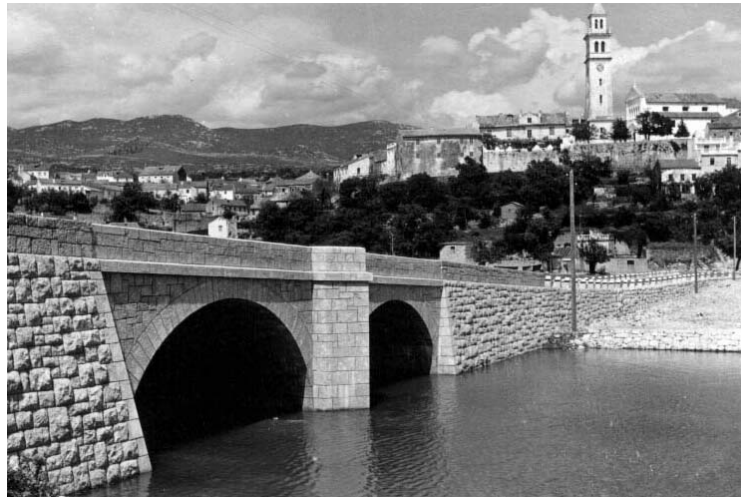


Figure 8. Novi Vinodolski bridge.



Figure 9. Plitvice bridge over Korana river.

4 THE DESIGNERS APPROACH

Frković was constantly overtaken with exploration of the form and shape as well as the aspiration for economical construction.

Basic features of Frković approach to bridges can be summarized in a few principles:

/1/ Aesthetic values are an essential part of his work and show that nothing is accidental and that the author pays particular attention to form and harmony of general lines of the bridge including every little detail. His works speak of a great patience of the author, of the

perfect knowledge of aesthetic laws but also of the natural gift for beauty.

/2/ Rationality of structures is evident in adaptability to the usage of locally available materials. Frković built stone bridges in Lika and littoral regions, masonry bridges in Slavonija, steel bridges on locations where traffic had to be established quickly, and combined different building materials where reasons and conditions were present allowing for monumental bridges.

/3/ Interdependence of design and construction included already in his initial design and evident from his role not only as designer but also as site engineer.

This is confirmed by here presented arch bridges designed and built by Frković.

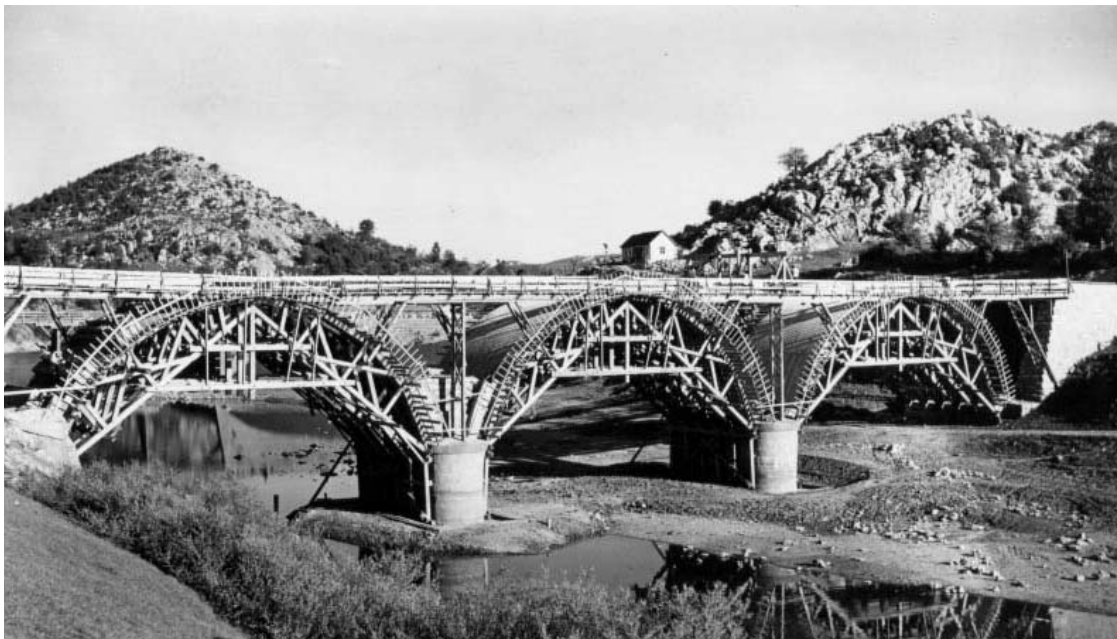


Figure 10. Centering for Kosinj bridge.

REFERENCES

- [1] J. Radić, Z. Šavor, S. Pičulin, G. Puž, "Large Concrete Arch Bridges in Croatia", Proc. ARCH'01, Third international arch bridges conference, Paris, pp. 49-58, (2001)
- [2] J. Radić, "The Origins of the Zagreb School of Bridges", *Annual 2001 of the Croatian Academy of Engineering*, Croatian Academy of Engineering, Zagreb, 47-53, (2001)
- [3] M. Ursinsky, *Die Technische Hochschule in Agram*, Druck von Ing. Granitz Agram, Zagreb (1889)
- [4] J. Radić: *Pontifex maximus*, Dom i svijet, Građevinski fakultet i Jadring, Zagreb, (2003)
- [5] K. Tonković, "Posljednja godina inženjera Frkovića" (The last year of engineer Frkovic, in Croatian), *Građevinar* **5**, 212-216 (1953)