The most long-lived bridge in the world

The Most Long-lived Bridge in the World

Le plus ancien pont du monde encore en service

Die älteste noch befahrbare Brücke der Welt

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To join our members of IABSE in celebrating the 65th birthday of our President, Dr. STÜSSI, I send this little article to wish him long life and ever greater success in his profession of bridge engineering.

Instead of reporting the scientific and technical achievements towards the remarkable progress of the bridges and structural engineering in today's China, which would need too much space in this Publication, I choose to give a short account on one of the notable features of the bridges in China, from the remote past to the present. This feature is the bridge's long life.

It is only too evident that a bridge engineer should aim to give long life to his bridges (as well as to give himself), but theoretically, just how long the life of a bridge could be, is usually a question not easily answerable. Even today, we are still unable to construct a bridge that would have just enough serviceable length of life not to fall short of the traffic needs and yet not too long to disturb the economic balance of the engineering program. As a result, what a bridge engineer would naturally incline to do is to strive to make the bridge as permanent as possible, so far as the available materials and labour skill would seem to guarantee. But how permanent? With modern technology in metal structures and reinforced or pre-stressed concrete, could we build a bridge to last three hundred years, a thousand years, or a thousand and three hundred years?

Here is an old bridge in China which was built approximately one thousand and three hundred years before the birth date of our President, Dr. STÜSSI, and yet has been continuously in service for road traffic from its very existence up to the present moment. Within my knowledge, this is perhaps the most long-lived bridge in the world! As shown in the attached photograph, this

bridge might easily be mistaken at a glance as an elegant modern structure. (Just as old men often looked young!)

This bridge, well known as Chao-Chow Bridge all over China, is situated near Shi-Jia-Zhuang, about 350 km south of Peking. It was built of a stone arch, with a single span of 37.4 m.

Stone arch is the symbol of Chinese bridges because it has been so popular in the country that even today, wherever you travel, you cannot fail to catch a sight of it. It is still unknown when it first appeared on the land, but some record says it started 250 B.C. In Chinese literature from the earliest times, can be found precious records depicting the progressive developments of stone-arch bridges. Chao-Chow Bridge, however, has many outstanding features that surpassed all its contemporary bridges not only in China but probably also in the world. It is interesting to note several of its features accomplished 1365 years ago.

The span length of 37.4 m is unique at a time when most other stone bridges had spans much less than half this size. This was necessitated by the fact that the river under the Bridge was rather torrential in flood times and would be much blocked by piers in the channel.

The shape of the arch was made a segment of the circle, with a rise of only 7.23 m. This type of a flat arch was very rare among old arched bridges where the curve was usually semi-circular, because of the difficulties involved in its construction. To cope with the situation that heavy animal carts had to climb up the Bridge, a very gentle slope of the arch was here much preferred.

The arch ring was made of cut stones about 0.30 m thick and 1.03 m wide, forming a ring of almost uniform width yet maintaining a very slight "waist" at the crown. The stone blocks were ground with smooth surfaces so that they could be pressed together tightly without using mortar. This prevented distortion of the arch through expansion and contraction of the mortar joints following contact with water.

The lining of the arch was of the "transverse" type, consisting of 28 separate narrow arches laid side by side to make up the width of 9 m of the roadway. This type was adopted probably because of the advantage that if any one of the single arches were to collapse, the bridge would still be standing safe for traffic. It had further the merits that for erection, the timber centering would need only to support a few of the single arches and could be moved along the width of the bridge each time the single arches were finished. For repair, only those damaged single arches would need be dismantled without affecting the other single arches which remained to support the roadway. In order to secure solidarity of the main arch, various devices were invented to hold together the 28 individual arches.

The most astonishing feature of the Chao-Chow Bridge, however, is the four small arches atop the main arch, two at each shoulder, to help support the roadway. They serve to lessen the load on the main arch as compared

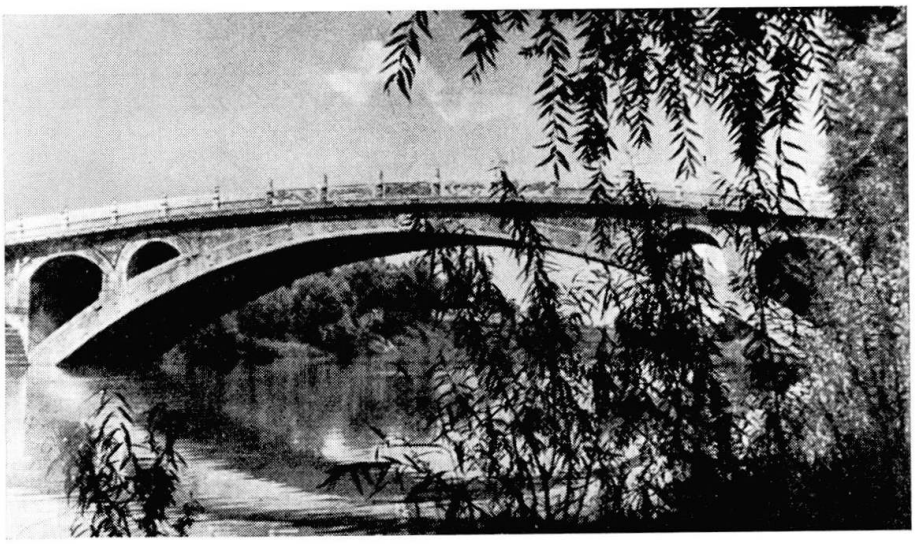

Fig. 1.

with an earth-filled or stone-filled arch bridge and act as spillways when the river is over flooded, thus reducing the water pressure on the arch. This type of open spandrelled arch was known to be used outside of China only seven hundred years later in the Pont de Ceret in France and was not prevalent in Europe until the middle of the nineteenth century.

Undoubtedly, all the above technical features combine to produce effects in prolonging the life of the Bridge. It is even more surprising that this was realized amid unaccountable mishaps of floods and droughts in the area of the Bridge, added by destructible damages to the bridge proper caused by civil wars and earthquakes within the bridge region. The Bridge has kept its shape intact against all these mechanical and weathering agencies throughout the long years of more than thirteen centuries.

From scientific point of view, the success of the technicality of Chao-Chow Bridge must have sufficient theoretical background to rely upon, though entirely unknown to the original builders of the bridge. They based their design and construction simply upon their own experience and intuition. It is worth remarking that until today, there are still many obscure points concerning the strength and rigidity of the Bridge not easily explanable. For instance, though the Bridge was designed for animal carts and pedestrians of old bygone days, yet since the Bridge formed a part of modern highway, thereby subjecting to the use of heavy motor trucks, it has wonderfully withstood the ever increasing load without apparent sign of failure. If we were to analyze the internal stresses of the Bridge according to modern theories of masonry arches, we would find that the Bridge is absolutely unsafe under those heavy trucks daily passing through. This is similar to what we would obtain concerning the case of an old bridge foundation. This shows that in building the Chao-Chow Bridge, many valuable scientific principles were used

unconsciously and that if we were able to expose them to light, it would enrich much towards our sience of bridge engineering.

It is due to the eminent superiority of Chao-Chow Bridge that its open-spandrelled form was adopted by a great number of arch bridges in various places in China during the thousand years thereafter. The most spectacular example is the open-spandrelled stone arched bridge for highways with a single span length of 112.54 m and ten small arches atop the main arch. It was completed in 1961, using modern methods for design and erection.

Besides its scientific and technical contributions towards bridge construction, Chao-Chow Bridge remains also as one of the most beautiful artistic specimens in Chinese architecture. It is both impressive and gracious by itself, not to speak of the exquisite decorative carvings on the parapet walls and little pillars on the sidewalks. For long times Chinese poets and artists have liked to refer the Bridge as "A Long Rainbow resting upon Gentle Waves".

It is very fortunate that the name of the "Chief Engineer" of the superb Chao-Chow Bridge was inscribed on the stone tablet that commemorated its great service after completion. Thus we know that he was Li Chun and that he lived during the Sui Dynasty (A.D. 581—618), but no clue has yet been found as regards his other works or his life.

Owing to its tremendous cultural value to the Chinese people, the Chao-Chow Bridge was thoroughly repaired and renovated by the People's Government in 1959 for better service today and ever longer life in the future.

Summary

The author describes the Chao-Chow Bridge, an arch with a span length of 37.4 m which was built more than 1300 years ago.

Résumé

L'auteur décrit le pont de Chao-Chow, une arche de 37,4 m d'ouverture construite il y a plus de 1300 ans.

Zusammenfassung

Der Verfasser beschreibt die Chao-Chow-Brücke, einen Bogen von 37,4 m Öffnung, der vor mehr als 1300 Jahren erstellt worden ist.