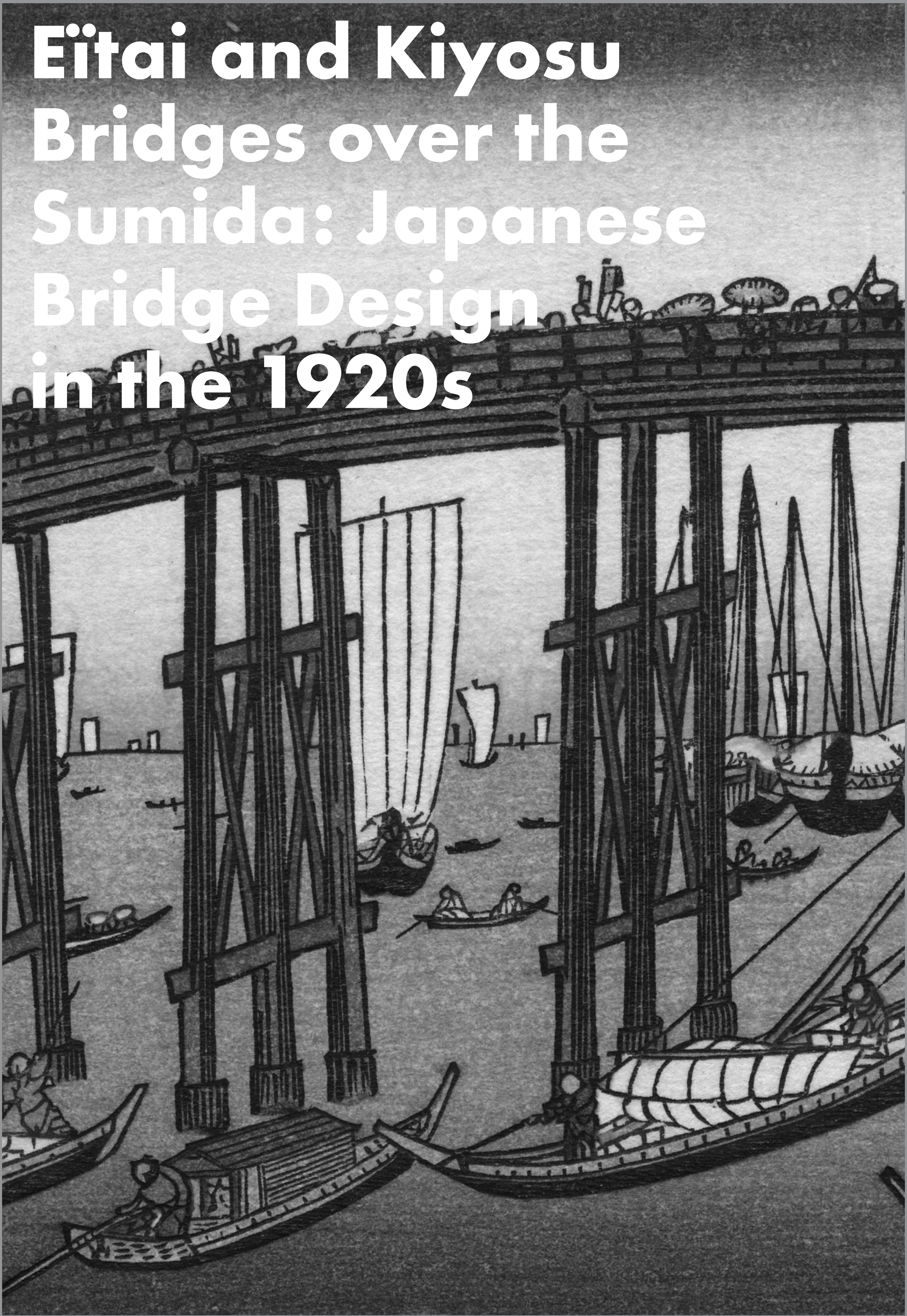
Eïtai and Kiyosu Bridges over the Sumida: Japanese Bridge Design in the 1920s



AFTER the earthquake of 1923 which devastated Tokyo, Japanese engineers worked on reconstruction to generate a new Modern landscape in the capital, taking into account various arguments ranging from science to culture. The construction process of the Eïtai and Kiyosu bridges over the Sumida River are indicative of this development. This paper will describe this process to better understand Japanese bridge design in 1920s in terms of technology and aesthetics.

By Daijiro Kitagawa

THE Sumida, the main river flowing through Tokyo, has always been a key place for Japanese bridge builders and engineers to display the technological progress of the times. Close to the seaport, the bridges had to span a large mouth of the river without impeding the passage of boats or ships [figure 1]. In terms of design, the imposing scale of these new structures expressed the power of a metropolis. Before, the connection between the banks of large rivers had been commonly ensured by small ferryboats.

The introduction of Modern industrial technologies, which began in the middle of 19th century, brought radical changes to the form of civil structures. The Sumida, along with the Yodo River in Osaka, was among the first major Japanese rivers to be equipped with metallic road bridges. In particular, one of the first steel road bridges in the country, consisting of 200 foot trusses, was built in 1897 at the very mouth of the Sumida[1] [figure 2]. The hybrid landscape along the river, which was composed of traditional buildings and 'westernized' bridges, symbolized the modernization of Tokyo.

In the same spirit of modernization, from 1920 a new urban planning for a Greater Tokyo began to be examined. During the same period, a cultural movement yearning for new urban aesthetics also occurred. This movement was influenced, among other things, by the City Beautiful Movement in the US. However, urban improvement of the capital became all the more urgent and indispensable in light of the devastating earthquake of 1923 that reached a magnitude 8.2 on the Richter scale, and of the ensuing fires that caused extensive damage to the city. Concerning the bridges, among the 657 that existed in Tokyo, a total of 69 structures were damaged and 289 burned down.

The challenges for civil engineers were no longer simply to satisfy the political, economic and cultural requirements of a fast-growing society, but to make the 'Imperial city' more resistant against natural disasters. Once again, the Sumida became a space to showcase engineering achievements, especially through the erection of the Eïtai and Kiyosu bridges.[2]

< Figure 1. The timber Eïtai Bridge, mid-19th century. Source: JSCE.

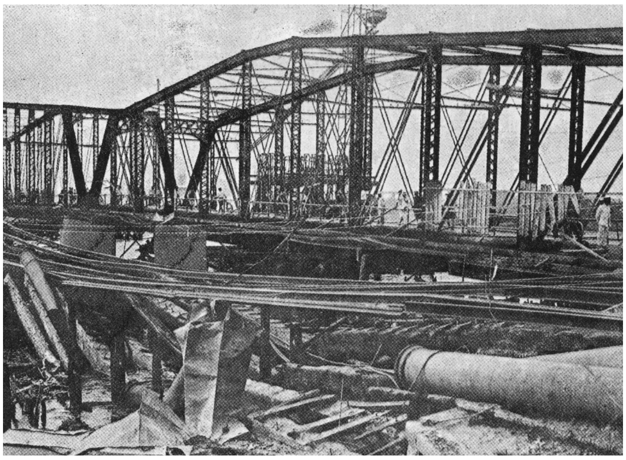
Towards a Quake-Resistant Bridge

The Eïtai and Kiyosu bridges [figures 3, 4] were among the 115 bridges constructed by the National Bureau of Reconstruction during the recovery process in Tokyo.[3] Interestingly, all these structures have a common technical feature: none opted for a truss type. For steel bridges, the structures adopted a plate girder to main beam regardless of their span. One of the lessons learned from the disaster was indeed to secure the rigidity of members and joints to avoid any possible deformation of the structures caused by strong vibrations.

Comparative drawings for the bridges over the Sumida in 1924 show that this idea was not unanimous from the beginning of the project [figure 5]. Nonetheless, the technical conviction of chief engineer Yutaka Tanaka was decisive in leading the Bureau to select n° 5 for the Eïtai (and not n° 3 or n° 4), and n° 6 for Kiyosu (and not n° 1 or n° 2).

Apart from this general point, what were the technical advantages of two bridges?[4] Firstly, the use of the pneumatic caisson method should be highlighted. The ground conditions were not favorable to place a massive structure. Therefore, the Bureau decided to summon Junzo Masago, an engineer that had worked at several firms in the US after graduating from Washington University. He was hired to carry out the work in collaboration with American Engineers at the Foundation Company. Seeing that it had taken so long to implement a similar project previously in Korea in the Japanese-Governed period, the Bureau expected American assistance would enable them to shorten the construction time and accelerate the recovery process. Even if this application of the pneumatic caisson method came late, it was nevertheless meaningful in the history of engineering in Japan, for this full-scale experience triggered its generalization all over the country.

Yet, the problem of the soft ground was not completely resolved by improving the foundations. To address this issue, Tanaka and his superior Enzo Ota, Director-General of the Engineering Department of the Bureau, adopted a



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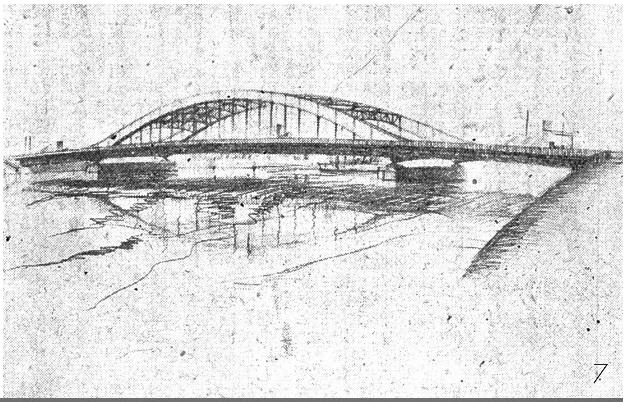

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tied arch system for the Eïtai bridge and a self-anchored system for the Kiyosu Bridge to remove excessive horizontal stress to both banks. A cantilever system was also used in both these cases to attenuate vertical loads to the anchors.

Finally, 'Ducol steel', a high-tensile manganese steel, was used for the first time for these bridges. This material had been developed in 1921 for the building of battleships by the Royal Navy of the UK. The Bureau, having researched all engineering fields, applied this technology to both bridges to lighten and strengthen the structures.

In Search of Modern Bridge Aesthetics

It is interesting to note that these technical challenges were closely linked to aesthetic issues. From the beginning of 20th century, several Japanese engineers had become interested in the question of the beauty of Modern bridges alongside the pursuit of cutting-edge technology. This discussion ranged from philosophical to practical issues.[5]

Ota dreamed of giving a new form to Japanese civilization through reconstruction works. He thus organized an informal working group of artists and writers—Ryunosuke Akutagawa among others—to obtain proposals for a

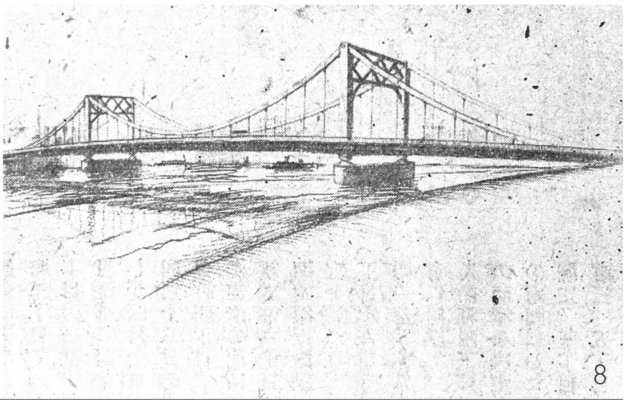
Figure 2. The Eïtai Bridge of 1897, damaged by the earthquake and fire in 1923. Source: JSCE.

Figure 3. The Eïtai Bridge, constructed in 1924–1926. Photo by Daijiro Kitagawa.

Figure 4. The Kiyosu Bridge, constructed in 1925–1928. Photo by Daijiro Kitagawa.

Figure 7. Drawing of the Eïtai Bridge, probably done by **Takizo Okamura**, future **Bunzo Yamaguchi**. Source: *Gendai Tsushin*, 1925.

Figure 8. Drawing of the Kiyosu Bridge, probably done by **Takizo Okamura**, future **Bunzo Yamaguchi**. Source: *Gendai Tsushin*, 1925.



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new bridge style for Tokyo. Mamoru Yamada and Bunzo Yamaguchi, two architects from the Ministry of Post and Telecommunication known as members of the Japanese 'Sezession' group, had also joined the Bureau to participate in the enterprise. Meanwhile, over 2,000 pictures of bridges all over the world were collected, probably at the request of Ota, to serve as a database of bridge design.

Although most of the informal proposals were unrealistic and as such, difficult to materialize, the many discussions among artists, architects and engineers had finally led to the formulation of a principle.

Get rid of false belief that a decorative bridge be beautiful! The intrinsic beauty resulting from mechanics theory is major part of bridge aesthetics. […] From a standpoint of the 'Spirit of Reconstruction' too, we should abandon frivolous and unwholesome decorations as well as decadent tastes, and go back to the right way of the design of civil structures."[6]

The rejection of trusses could be explained from this idea of the 'Spirit of Reconstruction' as well. In the case of the Eïtai Bridge, its massive solid rib arch was an expression of power, which a truss bridge—a 'big bird cage' according to Ota—could not fully render. The Kiyosu's firm form of chains stiffened by plate girder was also intended to represent gracefulness without giving the impression of being 'frivolous' or 'decadent' through the use of intricate compositions of thin members. In terms of mechanics, the Bureau adopted a real parabolic arch, inverted or not, instead of a false parabola formed from different sections of circle, as had been commonly applied until that time. In addition, the same sag was employed for the arch of the Eïtai and for the chain of the Kiyosu to emphasize a clear contrast between the form of these two bridges, which were located side by side.

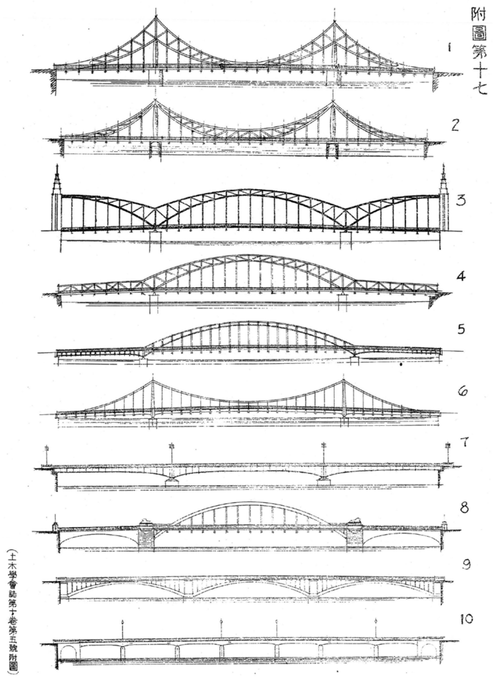
Nonetheless, for the Kiyosu, the above–mentioned principle only played a secondary role in leading the design. This suspension bridge had an obvious model in Cologne, the *Hindenburgbrücke*[7] [figure 6]. At a conference in 1928, Tanaka said that he had read an article on the competition for this bridge when he was a student at the University of Tokyo and felt the advent of a new age of bridge design.[8] The only architectural efforts were to make the main beam more slender in order to better express its elegance, taking advantage of the performance of Ducol steel[9] [figures 7, 8].

Conclusion

Oscillating between an imperative of quick recovery of national political and economic centre[10] and a desire to create a new, more modern and original Japanese civilization, engineers and architects may not have achieved their purpose entirely in this enterprise, considered by many to be the greatest that Modern Tokyo had ever seen. After the suicide of Ota, who was involved in a bribery scandal, his initial wish was materialized in a less visionary way under the direction of Tanaka, as he focused more on practical issues.

Nonetheless, these two bridges remain important references for the Sumida, in particular during the planning of the Kachidoki bascule bridge below the Eïtai from 1930. The initial decorative design would have been more suitable for the main entrance of the would–be World Fair in 1940 [figure 9]. In the end, however, it was modified in favor of a harmonization with the sober Eïtai Bridge. This occurred after the probable writer of *Spirit of Reconstruction*, Katsutake Naruse, was nominated as supervisor of this construction [figure 10].

The influence of these bridges reaches far beyond the area of the Sumida. Evidence of the prior use of plate girders in steel bridges can be widely observed in Japanese engineering works until the end of the Second World War. Even afterwards, they have inspired some engineers to better articulate technological developments with aesthetic issues. In this sense, the Eïtai and Kiyosu bridges can be considered as a precious heritage of our Modern urban landscape, demonstrating with utmost clarity the idea of Japanese bridge design in the 1920s.



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Notes

1. Concerning railway bridges, the first large steel structure was constructed in 1887 in another part of Japan. Railway engineering was always ahead of road structures at the beginning of the Japanese modernization.
2. Kitagava, Daijiro, "Classic of Modern bridge design in Japan", *Bridge and Foundation*, Tokyo, 05/2007. Nakai, Yu, *Thought of bridge design in Modern Japan*, University of Tokyo Press, 2005. (Both in Japanese).
3. In total, 425 new bridges were built after the earthquake in Tokyo. The rest was charged by the City of Tokyo.
4. As for the financial aspect, a sixth of the budget for the construction of all 115 bridges was devoted to these two bridges.
5. As a continuation of discussions, Modern Japanese–style bridge was searched in the 1930s and 1940s under an atmosphere of nationalism.
6. *Reconstruction works of Imperial city Tokyo*, The Bureau of Reconstruction, 1931. Original text in Japanese.
7. This competition was rather controversial, as described by Roland May in his paper. Roland May, "Discovering Construction as an Art—The 'Cologne Bridge Quarrel'", *Proceedings of the Third International Congress on Construction History*, Cottbus, 2009.
8. Tanaka, Yutaka "Bridges over the Sumida", Journal of Public works and Architecture, vol. 6–1, 1928. (in Japanese).
9. R.I.A., *Architect Bunzo Yamaguchi*, Tokyo, Sagami–Shobo, 1982. (in Japanese).
10. The recovery works, including the construction of 425 bridges, were concluded in 1931.

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Figure 5. Comparative drawings for bridge design over the Sumida by the Bureau of Reconstruction in 1924. Source: Enzo Ota, "About reconstruction works of Imperial city Tokyo", Journal of JSCE, vol. 10–5, 1924.

Figure 6. The *Hindenburgbrücke* over the Rhine, constructed in 1913–1915 by **M.A.N./Grün&Bilinger/Carl Moritz**. Source: Heribert Reiners, *1000 Jahre Rheinischer Kunst*, 1925.

Figure 9. Plan of the Kachidoki Bridge in 1930. Source: *Doboku-Kenchiku Gaho*, 1930.

Figure 10. The Kachidoki Bridge, constructed in 1932–1940. Photo by Daijiro Kitagawa.

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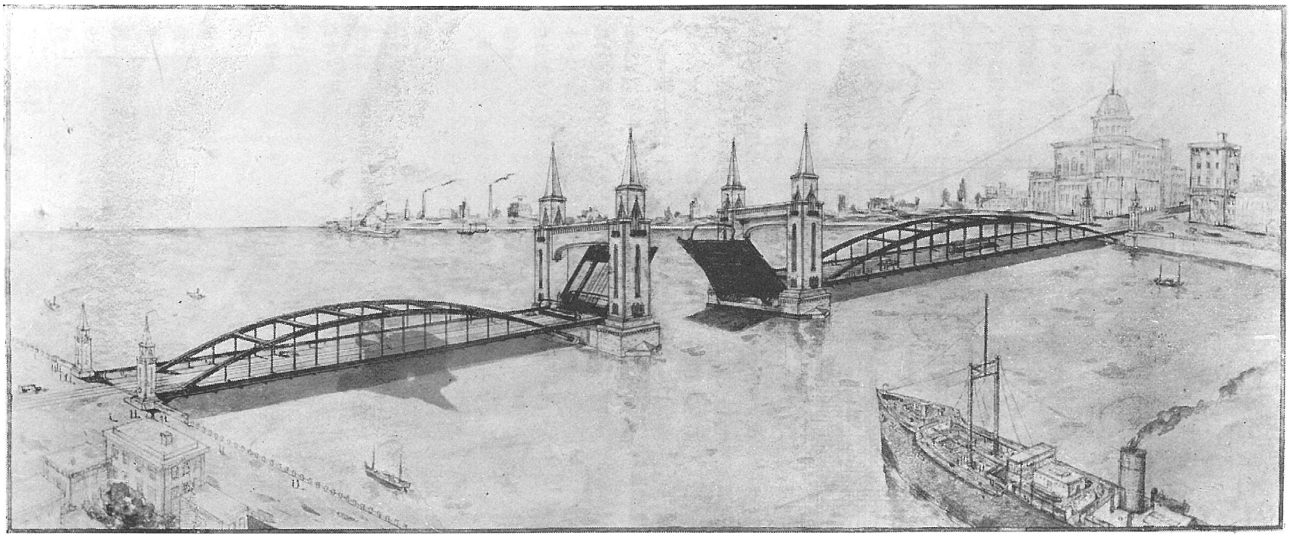

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