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Design and Construction of the Hokawazu Bridge

Conception et réalisation du pont de Hokawazu

Entwurf und Ausführung der Hokawazu-Brücke

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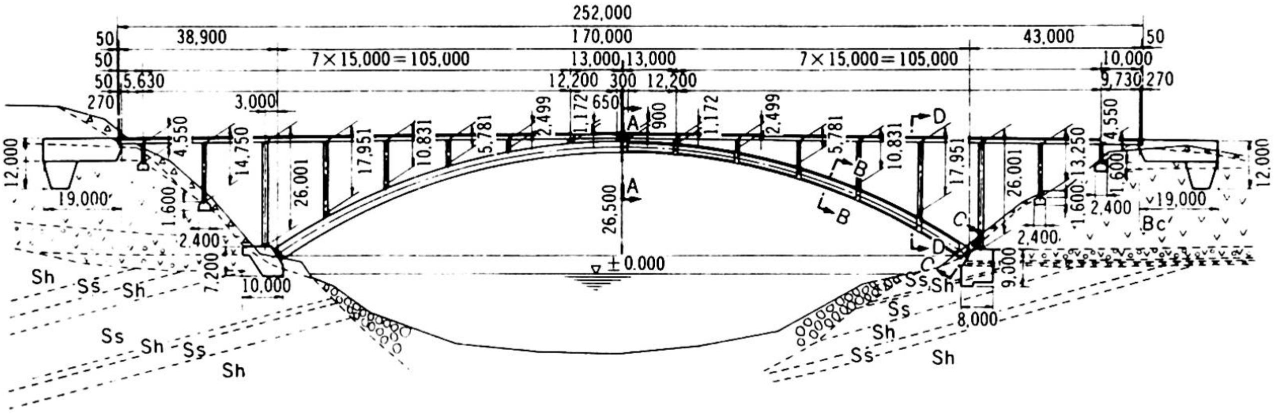
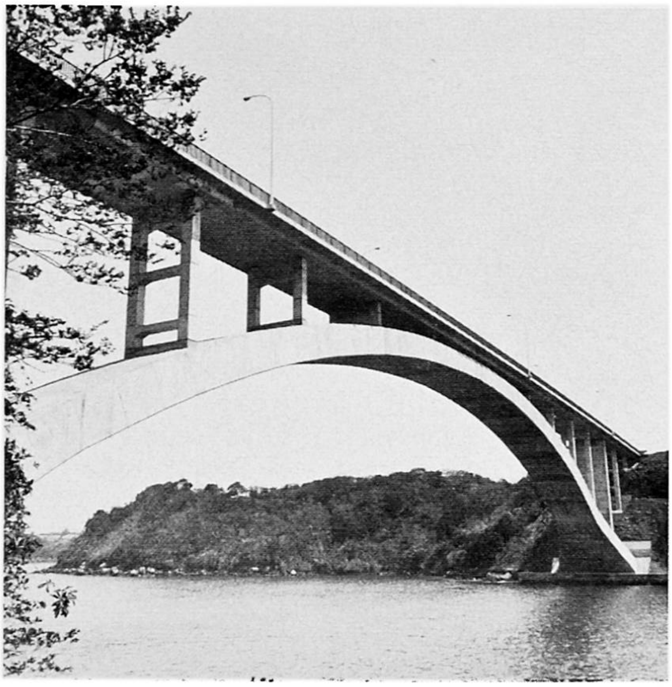
1. Preface

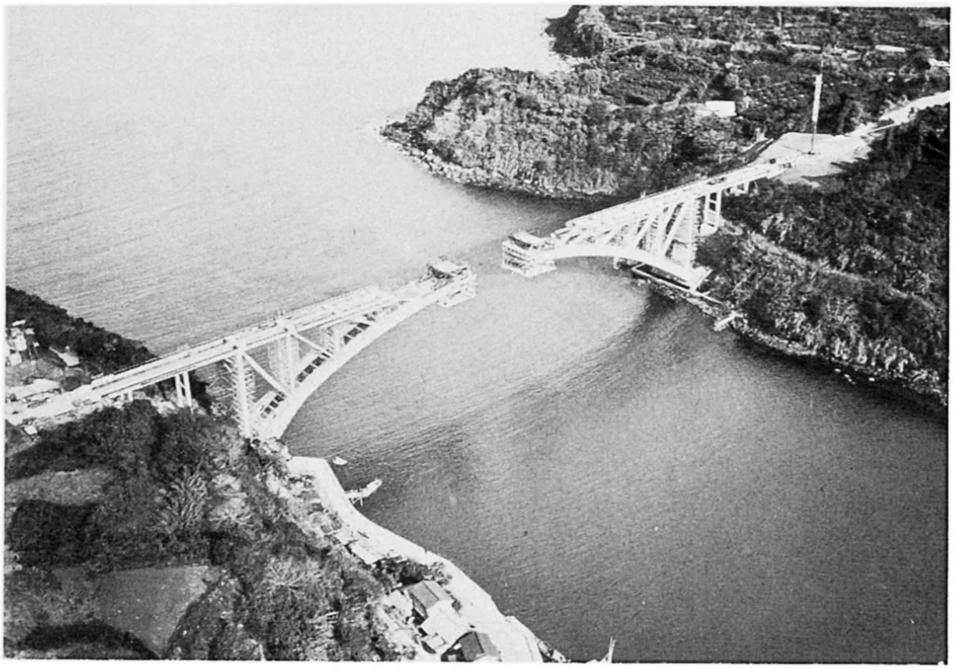
The National Highway Route 204 starts from Karatsu City in Saga Prefecture, goes along the Sea of Genkai, runs through Imari City in the same prefecture, and leads to Sasebo City in Nagasaki Prefecture, and the total length of the route reaches upto 154 km. The Hokawazu Creek made the route discontinuous between Chinzei and Genkai at Higashi-Matsuura County in Saga Prefecture, and transportation between these two towns depended upon ferryboats only. But the openning of the Hokawazu Bridge on May 1, 1974 dissolved the inconvenience in transportation in this area and the bridge is expected to be a "bridge" toward the prosperity of the region.

The Hokawazu Bridge, with a center span of 170 m and a total length of 252 m, is the longest reinforced concrete arch bridge in Japan, and was built by means of a new construction method unprecedented in the world. Since the adoption of the traditional staging construction method was difficult for the reason that the bridge is located on the sea and its floor level is too high (about 50 m above the seabed) to build a staging, a cantilever construction method was adopted in which the constructing segments formed of an arch rib, struts and floor slabs were supported by prestressing steel bars and the overhanged bodies extended their length step by step from both the shores toward the center until the final segment was placed at the center.

GENERAL VIEW







(1) Intent of the design

Reinforced concrete arch bridges are generally constructed with the help of stagings such as "arch center". But in this bridge, a cantilever construction method was adopted, in which the constructing segments formed of an arch, struts and floor slabs were supported by prestressing bars and, therefore, it was necessary to analyze each of the struts and the floor slabs as well as the arch rib, as a part of a cantilevered structure.

The design calculation by a computer with a large capacity was made for every temporary structural system corresponding to the growth of the arch rib, struts and slabs, conditions of falsehood and other equipment, as well as for the final structural system.

(2) Outline of the design

1) Arch rib

The arch rib, with a cross section of two boxes, was designed as two hinged structure.
The span length and the rise of the arch are 170 m and 26.5 m, respectively. The arch rib has a height of 3.0 m at its springings, 2.4 m at the crown, and has a width of 8.0 m except the portions of the nearest 19 m from the springings where it was increased lineally from 8.0 m to 16.0 m providing the maximum at the springings for the reason of improvement of stability against lateral seismic and wind forces perpendicular to the bridge axis.

2) Struts and piers

Struts on the arch rib range from 17.951 m to 0.635 m in their heights, and were designed as rigid frame structures of one to five stories. Top and bottom ends of each strut have steel pin bearings so that the strut can behave as a rocking pier absorbing the large amount of bending moments due to the inclination of the strut by the over-raising of the structure during the construction and by the influence of temperature changes, creep and shrinkage of the concrete.

3) Floor Slab

Continuous hollow slab, over nine spans and 60 cm thick, were adopted because it was important to decrease the dead weight of the slab in such cantilever construction.

4) Abutments

Abutments of large dimensions at both ends of the bridge were necessary as anchorages against the overturning of the cantilevered structural parts during the construction, and such large dimensions are not necessary for the stability of the bridge after the completion.

5) Abutments for arch rib

The maximum axial compressive force in the arch rib at its springings is approximately 5000t at the time of construction and 6700t at the final stage of completion. The axial force is transmitted to the abutment for the arch rib through a large bearing which consists of four steel pin bearings.

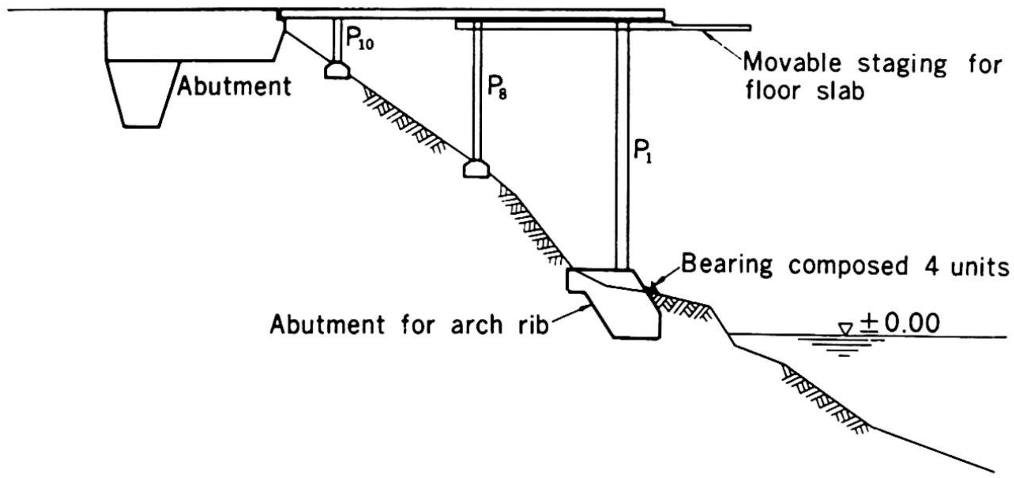
The dimensions of the abutments reach 20 m in width, 9 m in height and 8 m in length.

Construction

(1) Construction process

1) Construction of side spans

i. Concrete placing for abutments and piers
ii. Placement of 76 prestressing steel bars on the surface of the floor slabs.
iii. Placement of four bearings (capable of 1655t reaction by a bearing) for the arch rib.



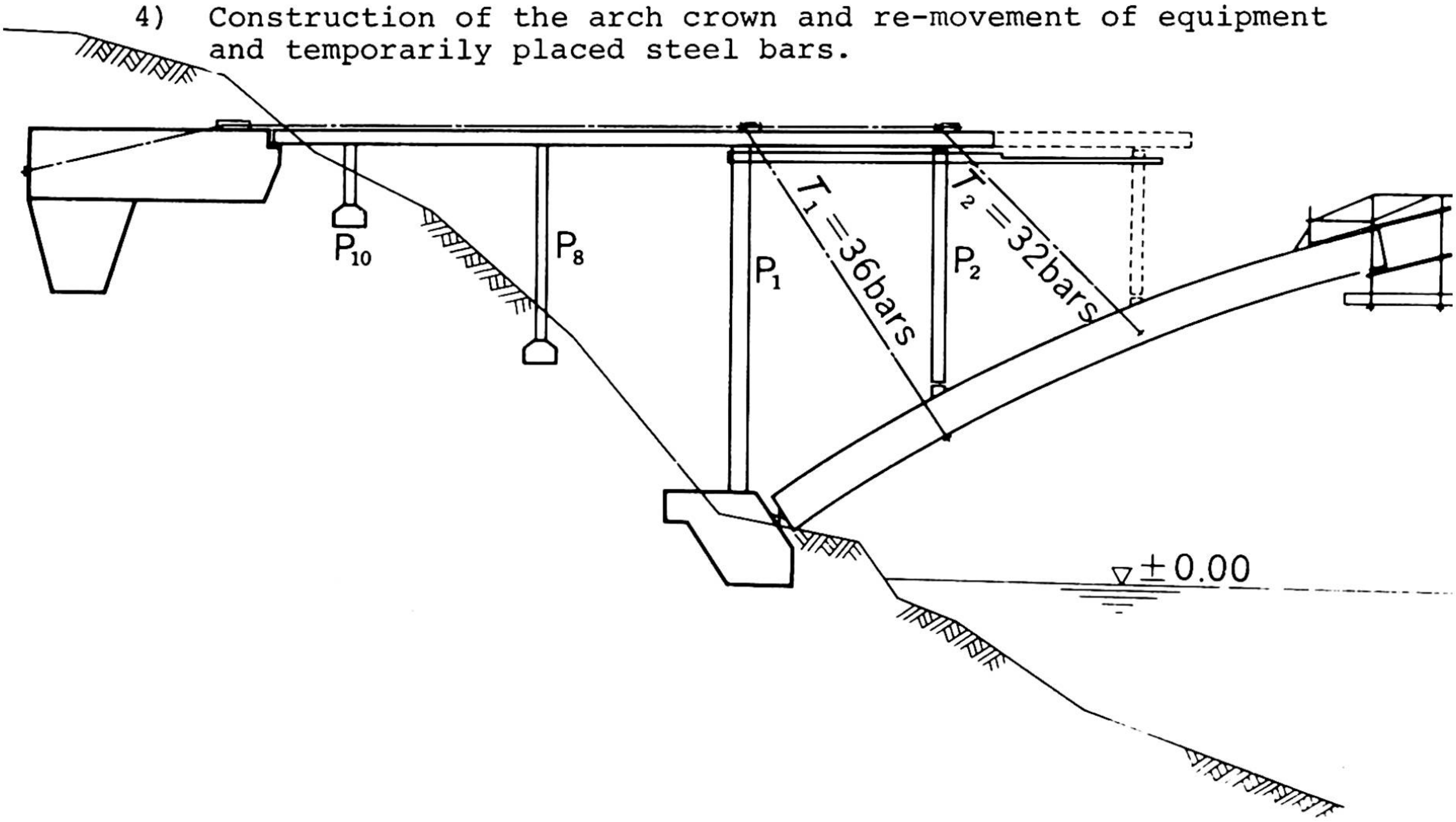
2) Construction of a part of the arch rib on suspended falseworks

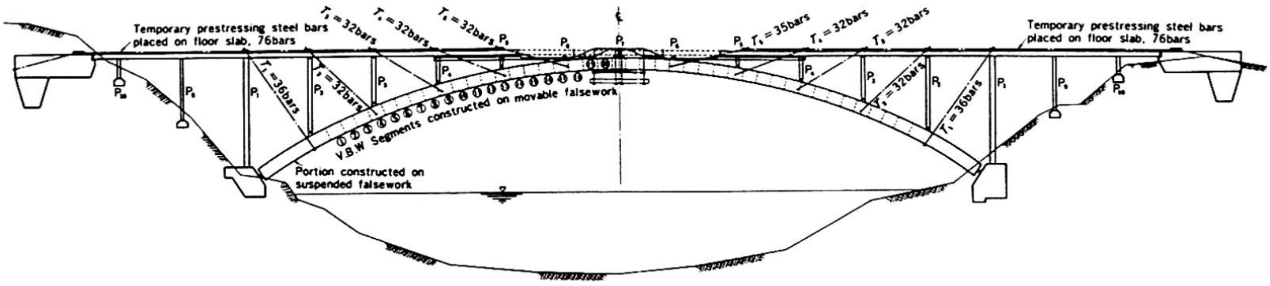
   i. Placement of steel panel girder falseworks suspended by 36 inclined prestressing steel bars, T_1, in the portions between P_1 and P_2.

3) Construction of the consecutive part of the arch rib on movable falseworks

   i. Construction of the arch rib between P_1 and P_2 by cantilever construction method on the "Wagen".
   ii. Construction of struts, P_2, followed after the above stage.
   iii. Construction of the floor slab between P_1 and P_2 on movable falseworks.
   iv. Placement of 32 inclined prestressing steel bars, T_2, and of prestressing steel bars on the floor slab between T_1 and T_2.
   v. Advancing the above processes and completing the arch rib except the arch crown.

4) Construction of the arch crown and re-movement of equipment and temporarily placed steel bars.





POSTSCRIPT

There have been a lot of reinforced concrete arch bridges since considerably old times. In every case of them the major problem to be solved was how to erect the structure. But we are sure that the erection method developed in this Hokawazu Bridge work can be a step to solue it. As arch-type bridge is a most hopeful structural system among concrete bridges of large span which are supposed to become very popular in future, we would be much pleased if the data of this bridge could greatly contribute the establishment of an effective erection method.

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SUMMARY

This paper describes a special method applied to the construction of a reinforce concrete arched bridge with a length of 252 m and a central span of 170 m. The conventional staging method is not employed in the bridge erection and the whole bridge is overhung from the two banks and connected at the central crown part.

RESUME

Cet article décrit un procédé spécial utilisé pour la construction d'un pont en arc en béton armé, de 252 m de long et d'une travée centrale de 170 m. On n'utilise pas la méthode classique de l'échafaudage dans la construction de ce pont. Le pont entier est construit en encorbellement à partir des deux rives.

ZUSAMMENFASSUNG

Dieser Bericht beschreibt ein Spezialverfahren, das beim Bau einer Bogenbrücke aus Eisenbeton mit einer Länge von 252 m und einer zentralen Spannweite von 170 m angewendet wurde. Die herkömmliche Gerüstaufstellung wird hier vermieden. Die ganze Brücke wird von den zwei Flussufern her vorgebaut und im Bogenscheitel verbunden.