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DESIGN AND CONSTRUCTION OF THE OBORO CONCRETE ARCH BRIDGE

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1. ABSTRACT

The Oboro Bridge has been constructed at the northern entrance to Joyo-town, Yabe-county, a region in southern Fukuoka Prefecture that is known for fireflies and stone bridges. It is be a reinforced concrete fixed arch bridge that spans the Hirokawa Gorge, a V-shaped valley located in the Chikugo River Prefectural Natural Park.

Consideration was given to harmonization with the surrounding environment in the design of this bridge. Its major features are the bifurcated arch rib shape, upside-down V-shaped vertical members and other aesthetic design that gives the bridge an uplifting appearance. The construction plan incorporates computerized construction, done with the aim of reducing the number of erected members, as well as the diversion of erection members and so on. These actions were conducted in an effort to prevent the generation of industrial wastes and shorten the work time, thereby saving costs.

This paper will present an overview of the design and construction of the Oboro Bridge, as well as the computerized construction being used in its construction.

2. OVERVIEW OF CONSTRUCTION

Photo 1and 2 shows the completed bridge. The distinguishing characteristic of the structural form is that the arch ribs curve and widen from the crown to the springing section, and that they are bifurcated in the 45-meter interval leading to the springing section. The construction site is a V-shaped valley called the Hirokawa Gorge, and there is a height of approximately 72 meters from the river bottom to the surface of the bridge.

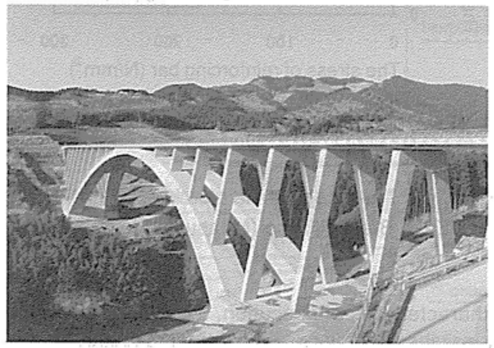

Photo1 Oboro bridge

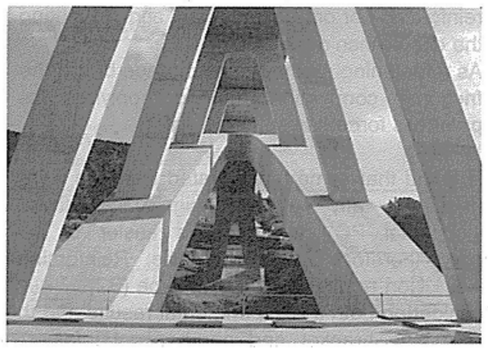

Photo2 Bifurcated arch ribs

3. COMPUTERIZED CONSTRUCTION

All displacement and stress (strain) data items were stored in the PC in the measurement control room set up on the site and transferred via a wireless network to the site office located approximately 100 m away. All PCs in this office were connected using a LAN, enabling the measurement data to be monitored from any PC. In addition, intercoms were used to enable continuous communication between the measurement control office and the pylons used to adjust the tension of the stays. When the tension of the stays and backstays was adjusted, the measurement data could be analyzed in real time and instructions given regarding the amount of tension adjustment.

4. INFLUENCE OF TEMPERATURE CHANGES ON ARCH RIB CAMBER CONTROL

The influence of temperature changes on shape control for arch bridges is complex and varied, as noted below, and it is extremely difficult to accurately determine and control these values. Their behavior can be roughly divided into the pre-closure Melan arches that are free in the lateral direction,

and the post-closure Melan arches that are constrained in the lateral direction. In addition, the different thermal transfer properties of steel and concrete and other factors also result in different behavior during the erection process, when many steel members are used, and in the completed system, which consists only of concrete members.

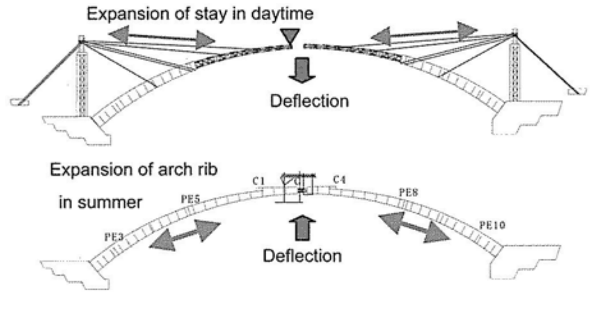

Fig.1 Arch rib deflection by temperature changes

(1) During Melan arch erection

During the Melan arch erection, the deflection in the arch ribs caused by temperature expansion and contraction of the stays became comparatively great. Just before closure of the Melan arches, the difference in deflection between day and night was about 40 - 50 mm.

Starting immediately after the closure of the Melan arches, the temperature expansion and contraction of the stays had no effect on deflection but appeared as fluctuations in tension. In return, deflection was produced in the arch ribs due to temperature expansion and contraction of the steel members in the Melan arch. Along with this, starting in the wee hours, when the Melan arches were closed, the deflection caused by changes in arch rib temperature during the day and during the night was reversed. Fig.2 shows the history of deflection at the ends of the Melan arches before and after Melan closure.

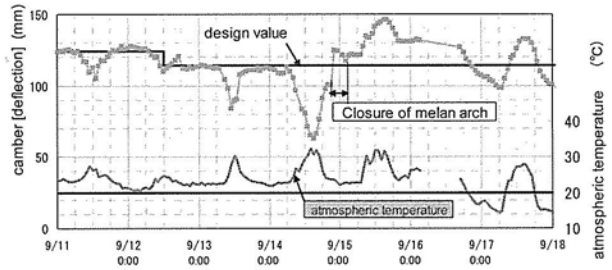

Fig.2 Melan arch deflection before and after closure

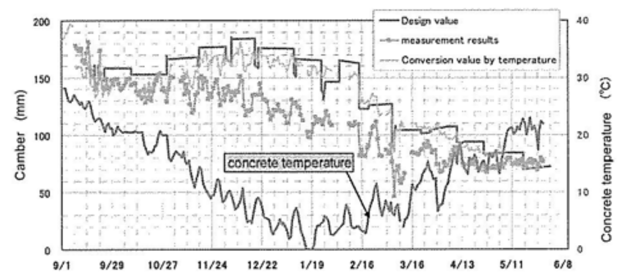

Fig.3 Arch rib camber during concrete jacketing

(2)Completion of concrete jacketing and post-completion

The steel members exhibited considerable change in temperature between daytime and nighttime. In contrast, the concrete showed almost no change in temperature between day and night. Accordingly, as concrete jacketing progressed, the difference in deflection between day and night disappeared almost completely. However, it is a well-known fact, that in this type of structure, seasonal temperature changes will cause considerable up-and-down fluctuation to continue even after the arch bridge has been completed. Fig.3 shows the measurements for deflection at the apex of the Melan arches during the concrete jacketing process. In winter, the measurements were about 40 - 50 mm, which was lower than the design values, but it can be seen that the measurements approached the design values as the average daily temperature rose.

Table1 shows the temperature conversions for arch rib deflection used during this work process. Table was used to convert the temperature for control of arch rib camber so the value was always 20℃, the height of the arch ribs was almost exactly in line with the design values.

Table1 Conversion of arch rib camber by rising temperature 10℃

		PE3	PE5	C1	C	C	C4	PE8	PE10
Immediately before Melan closure									
change in year	concrete temperature	0.9	4.5	8.4	10.6	9.5	7.8	4.0	0.8
change in daily	atmospheric temperature	−0.5	−6.5	−16.3	−22.2	−22.8	−17.6	−6.3	−0.5
Immediately after Melan closure									
change in year	concrete temperature	1.4	12.7	31.1	33.3		28.2	12.1	1.3
change in daily	atmospheric temperature	0.3	4.6	19.1	20.8		17.1	4.4	0.3
Completion of concrete jacketing									
change in year	concrete temperature	1.5	13.5	27.0	28.5		26.3	13.3	1.4