The “Great Himiyume Bridge”, Highway Entrance to Nagasaki
The world first extradosed bridge using corrugated steel plate webs

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It takes about 2.5 hours currently to go to Nagasaki from Fukuoka on the highway. You drive down south on the Kyushu Highway, enter the Nagasaki highway at the Tosu junction and head for Nagasaki via the Nagasaki Tarami interchange, the far west point in current service. After the whole line is opened, it will extend to Nagasaki interchange, 11.3 km south of the Nagasaki Tarami interchange.

The Himiyume Great Bridge is a three-clear-span continuous extradosed bridge, with an overall length of 365 m, located in Susukizuka-machi, Nagasaki City, approximately 4 km north of Nagasaki interchange, which is the starting point of the Nagasaki Highway. (Photo-1) The location of this bridge is at the crossing point of Route 34 and the Himi Bypass, and when it is completed, it is expected to be a new landmark as the entrance to Nagasaki, which is a city of history and romance. (Fig.-1) Harmony with the surrounding environment at the construction point was taken into consideration as the top priority from the beginning of the plan and as a result of enthusiastic study of the landscape and its structural form, an extradosed bridge using a corrugated steel plates web PC (prestressed concrete) box girder was adopted for the first time in the world.

The author had opportunities to visit this bridge under construction three times and learned about the technological characteristics in terms of the design and construction of this bridge in relationship to the surrounding environment. Here follows the introduction.

Photo-1: The Himiyume Great Bridge shortly before completion

Fig.-1: The location of the Himiyume Great Bridge

Photo-2: The Susukizuka Area at the time of the Nagasaki Great Flood in 1982 (Extracted from the website of Nagasaki Prefecture)

The reason for adoption of this structure style for this bridge

The Susukizuka Area, where this bridge is being constructed, was a clough where a total of 15 victims, missing and dead, and a great many houses were flooded and half broken by a great landslide and debris flow at the time of the Great Nagasaki Flood in July 1982 (Showa57). (Photo-2) At present, disaster countermeasures have been taken, for example, a sediment control dam was constructed, and it is designated as a "sabo" (sediment control) designated area. In deciding a location for laying the bridge piers in this kind of place, we considered it essential, as well as to avoid the basin of debris flow, to have a bridge with the greatest span of 150~180 m, out of necessity to select an area excluding Route 34 and the Himi Bypass, which are arterial roads to Nagasaki City running just in front of the abutments on both sides.

Also, there were the strict construction conditions, such as very steep terrain and an approach path to the bridge pier building spot that was restricted only through the national road, so the work on the national road had to be done only during night time. As a result of the examination and considering the construction rationalization and the shortened work period, an extradosed bridge was judged as the most advantageous structure to be adopted for this bridge.

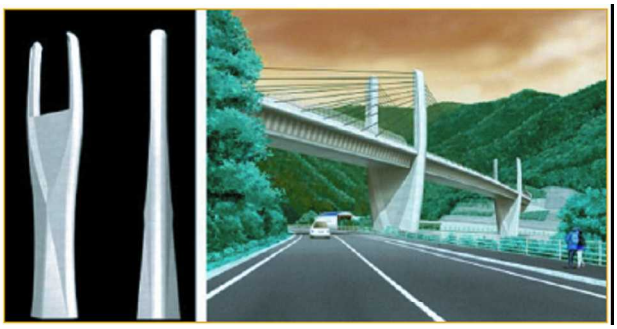

Fig.-2: The image of the bridge piers and the main tower

On the other hand, the construction place of this bridge is located at a place very close to the Himi New Route, and the Nagasaki Way which was designated as a historic national road, with a lot of houses built on the clough along the roads, and it is a very beautiful place that commands a magnificent view of Tachibana Bay. Thus, wishing the bridge to be in harmony with the surrounding rich environment including the view, history and nature, and at the same time, to be strong, elegant and beautiful to relay such things to the next century, we selected the structure style and the form of this bridge in which the bridge piers, that had a lot of soft curve lines, and the superstructure, that had slender and straight main girders, and the main towers were in excellent harmony. (Fig.-2)

What is an extradosed bridge using corrugated steel plate webs?

An extradosed bridge was named so by J. Mathivat, a Frenchman, in 1988. It can be said to be, so to speak, a structural style

interpolating an external cable girder bridge with a cable-stayed bridge. An extradosed bridge is a bridge in which the eccentricity of the PC steel was made larger by installing PC steel cables, which are usually inside the girders but in this case, outside the girders, thus it enables the cross section of the main girder to be made smaller than a regular girder bridge and the main tower height lower than a cable-stayed bridge. In recent years in Japan there are more and more cases of this structural application, such as the Odawara Blueway Bridge (1994) and the Ibi River and the Kiso River Bridge (2001). This is an excellent structure style in terms of being economical and having high construction efficiency for the span length interpolating the application span between a girder bridge and a cable-stayed bridge.

On the other hand, a corrugated steel plate web box girder bridge is a structure style developed and used also in France as a measure for weight reduction of the PC box girder. In other words, it is a rational composite structure that enabled the reduction of the dead load on the girder cross section, promoting labor saving construction, and improving the efficiency of introducing prestress to the concrete top and bottom floor boards by means of replacing the concrete web

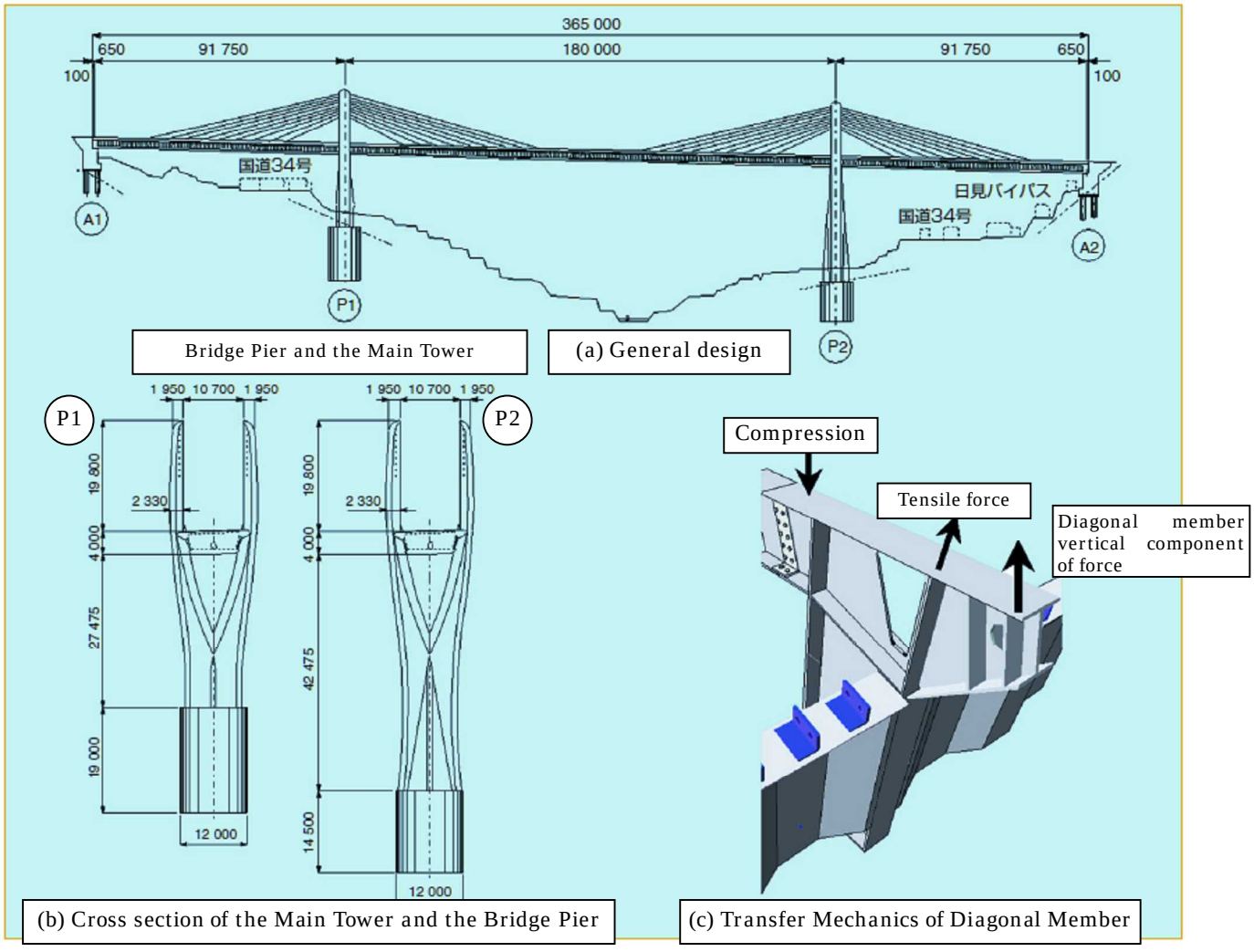

Fig.-3: The general design of the Great Himiyume Bridge and the mechanism of the diagonal member tensile force transmission of the diaphragm

that makes up 20-30% of the girder cross section weight with a corrugated thin steel web that is excellent in shear buckling strength and has a small compressive strength in the direction of the bridge axis, which is called an accordion effect. It was applied to the Cognac Bridge in France in 1986 for the first time, and in Japan, since it was applied to the Shinkai Bridge (1993) as the first case, there have been a lot of bridges constructed.

The structural characteristics of this bridge

This bridge was the first form in the world that combined two new structural forms that have been a focus of attention recently; a corrugated steel plate web PC box girder and an extradosed bridge as a suspension structure, as mentioned above, from the viewpoint of weight saving, construction efficiency and scenic attractiveness. In addition, the central span length of 180 m is one of the largest in Japan as an extradosed bridge as well as a corrugated steel plate web PC box girder bridge.(Fig-3) As a structural form of the same sort as this bridge, the Rittou-bashi, or the Second Meishin Highway, that is a box girder structure with three rooms of main girder cross section, is now under construction.

For this bridge, the Great Himiyume, under the severe construction conditions as mentioned above, measures for construction rationalization and shortening of the work period had been discussed and studied from the design stage, and various technological measures were taken into consideration. Some of them are introduced below:

Block break-up

The cantilever erection method by a traveler was adopted for this bridge. For construction rationalization and shortening of the work period, it was considered to make the one block length as large as possible. As a result of examining the block division and diagonal member pitch, setting the one block length at an integral multiple of 1.6 m, the corrugated plate length, the diagonal member pitch and the block length was decided at 6.4 m.

The structure of the diagonal member anchor point

As a result of design examination of the diagonal member anchor point of the main girder, as a structure that conveys the vertical component of force of the diagonal member appropriately to the corrugated steel plate web, and at the same time, as a structure meant to decrease the main girder's weight, the diaphragm structure whose both vertical and horizontal ribs were reinforced by steel members was selected, and it was decided to adopt a composite structure that can covey the vertical component of the force of the diagonal member efficiently to the main girder.

Verification by using a half scale model

Because this was an unprecedented new structural form, especially for the purpose of performance confirmation of the diagonal member anchor point structure as a composite structure as well as to have a correct understanding of the bending movement as an extradosed structure, a partial model sample on a half scale of this bridge was made and loading tests were carried out. (Photo-3) As a result, it was proved that there was no problem of the load equivalent to the designed load, and for the load equivalent of the ultimate load. It

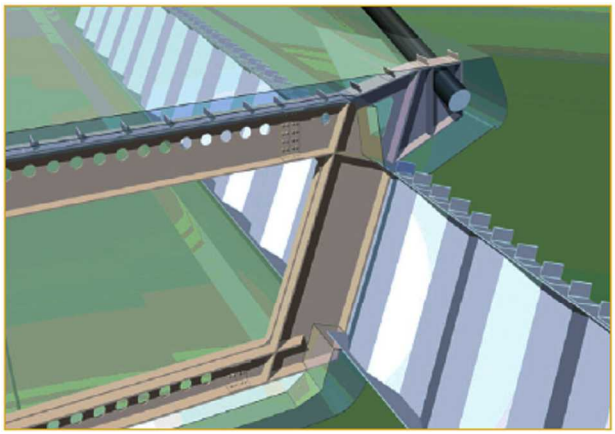

Fig. 4: The structure of the diagonal member anchor point

Photo-3: Experiment using a 1/2 model

was confirmed that there was little damage the joints, and the structural safety of this bridge and the validity of the design were verified.

By the way, this big model in the length of 10 m which was actually used in the experiment is now exhibited at the site of the field office of the cooperative consortium and is open to visitors.

Construction of the main tower

From the main towers, at the height of 20 m, standing on the bridge piers that are giving off a three-dimensional soft and sweet atmosphere, diagonal member cables are extending in good balance on either side of the bridge as the progress of girder construction (Photo-4). A compositional structure coiling concrete around a steel shell structure is applied for the main tower diagonal member anchor point of this bridge. The size of a steel shell is 2.5 m X 1.0 m, which is a metal touch structure that can exert the advantage of factory manufacture and labor saving on-site construction. The minimum thickness of the concrete around the steel shell is 300 mm, and an expansive admixture is added for the purpose of crack control and securing durability against the tensile force by the concrete shrinkage restraint and residual force.

Cantilever erection method by a traveler

The main characteristic of this bridge is, as mentioned before, a cantilever erection method using a super-sized special traveler. A steel diaphragm was adopted for the diagonal member anchor point, and the corrugated steel plates and diaphragm were welded and blended on the same web in the factory, and what was made that way was carried to the site at night and assembled on site by means of a lapped fillet weld of each other's corrugated steel web and the bolt connection of each member of each other's diaphragm (Photo-5).

In order to unify the corrugated steel plates, steel diaphragm and concrete, it was necessary to place the concrete closely and steadily. Especially, because there was fear about the shortage of concrete filling under the flange, filling tests were carried out, and air ducts were opened in the flange to control blister formation as well as a slump of 15 cm was chosen.

By re-using the steel form, the appearance of the main girder after completion is beautiful in color and in harmony with the corrugated steel plates. Also a wide open

Photo-4: Cantilever erection method by a traveler

Photo-5: On-site assembly of steel diaphragm

space can be perceived in the girders by using corrugated steel plates. It is really amazing to see that the blending of such different materials as steel corrugated web, diaphragms and concrete top and bottom flanges did not give any sense of discordance. Isn't it proof of the design and construction considered for harmony with the surrounding environment as well as a combination of different materials?

The Great Himiyume Bridge opened this spring

The connection of central parts will be made at the beginning of December 2003 and the bridge is expected to open to the Nagasaki interchange, which is the starting point of the Nagasaki Highway, this spring. Considering the current traffic congestion after getting out of the Tarami interchange, it is expected that the necessary time to go to the heart of Nagasaki City will be greatly shortened after the completion of the whole line. I heard that the name the "Great Himiyume Bridge", which was tentatively called the "Himi Bridge" during the construction period, was named by an elementary school student from among the citizens. I only hope that this bridge will be a highway to serve the vitalization and development of Nagasaki and the Nishi-Kyushu area where children can have big hopes and dreams for the 21st century, as the name means, while at the same time protecting the beautiful environment and history.

Lastly, I would like to express my sincere gratitude to the people involved at the Nagasaki Field Office, Kyushu Branch, and the Japan Highway Public Corp, which provided me with materials and information about the construction site, as well as the Mitsui-Sumitomo Construction Company and the Zendaka-gumi Consortium.

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