

Construction of precast segment bridge with consideration of biodiversity conservation

-The New Tomei Expressway Matoba Viaduct in Japan-

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ABSTRACT

The Matoba Viaduct is a continuous prestressed concrete box girder bridge located within the Hamamatsu-Inasa Junction on the New Tomei Expressway. The viaduct crosses the Matoba River, which is one of Japan's most important habitats for fireflies. Today, public works are expected to take the environment into consideration, so to ensure conservation of biodiversity, the design of the viaduct took special measures to minimize the impact on the river environment when constructing the main Matoba Viaduct and Ramp D Viaduct 3. To achieve these objectives, the viaducts were constructed by cantilever erection using precast segments so as not to require full staging at the site. This project incorporated proactive biodiversity conservation by working together with local residents and creating a biotope within the construction site where fireflies can lay their eggs.

Keywords. precast segment construction method, biodiversity conservation, firefly habitat conservation, cantilever erection

1. INTRODUCTION

The section of the New Tomei Expressway in Shizuoka prefecture between Gotemba Junction and Mikkabi Junction (Total length 162 km) went into service in early summer 2012, boosting the reliability of the transportation system by forming a double network with the existing Tomei Expressway. The Matoba Viaduct is a continuous prestressed concrete box girder bridge forming part of this new section, located within the Hamamatsu-Inasa Junction.

Special construction requirements for the Matoba Viaduct were conservation of the environment of the Matoba River within the construction site, and a short construction time

to enable the construction yard for the main viaducts and Ramp D Viaduct 3 to be handed over at an early date for pavement construction.

The Matoba Viaduct project consisted of a total of four viaducts, comprising the main up and down carriageway viaducts ("main viaducts"), Ramp C Viaduct 3, and Ramp D Viaduct 3 ("Ramp D-3"). With the exception of Ramp C Viaduct 3, which is positioned away from the Matoba River, each of these viaducts is designed to minimize the impact of construction on the river environment and to shorten the construction period by using precast segments erected by a cantilever erection. The project incorporated proactive biodiversity conservation by working together with local residents and creating a biotope within the construction site where fireflies can lay their eggs.

The main viaducts used cantilever erection of segments comprising the core section plus ribs. The deck slab is then cast in place after erection. This approach gives a prestressed concrete panel composite slab structure that is efficient to construct. For Ramp D-3, the complex linear shapes typical of expressway ramps required sophisticated management of the segment shapes, but this was successfully accomplished, completing the viaduct without problems. This report focuses on the design and construction technology that enabled a short construction period despite incorporating special measures to conserve the environment.

2. OUTLINE OF CONSTRUCTION

The three viaducts comprising this project are shown in Photo 1. The construction outline is given below, the locations are shown in Figure 1, and the general views of the structures are shown in Figure 2.



Photo 1. Over View

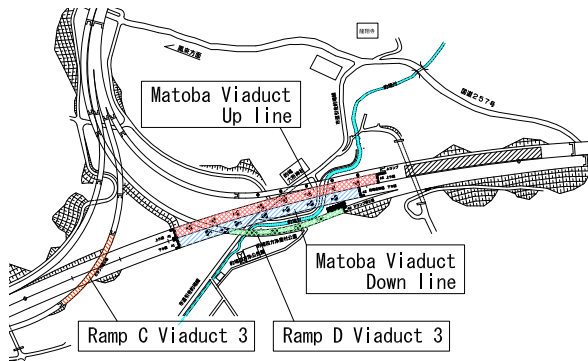


Figure 1. Locations

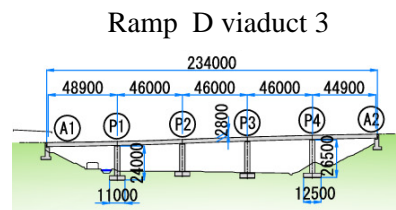
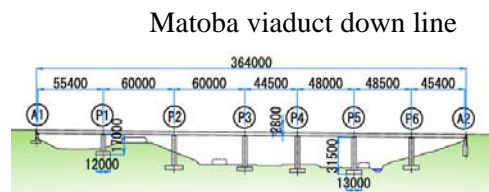
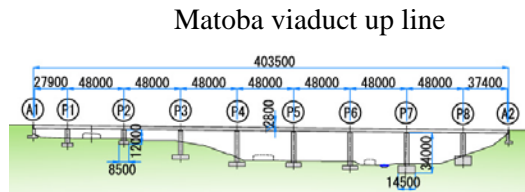


Figure 2. General views

Project: Daini Tomei Expressway, construction of Matoba Viaduct and 2 other viaducts (PC superstructure)

Client: Central Nippon Expressway Company

Tokyo Head Office/Hamamatsu Construction Office

Location: Matoba, Inasa-cho, Kita-ku, Hamamatsu, Shizuoka Prefecture, Japan

Term: April 21, 2009-August 16, 2011

Structural type: (Up Line) 9-span continuous prestressed concrete box girder bridge

(Down Line) 7-span continuous prestressed concrete box girder bridge

(Ramp D-3) 5-span continuous prestressed concrete box girder bridge

Lengths: (Up Line) 403.5 m, (Down Line) 364.0 m, (Ramp D-3) 234.0 m

3. CANTILEVER ERECTION USING PRECAST SEGEMENTS

For the main viaducts, the segments were transported along the viaduct and then erected using erection girder. For Ramp D-3, in order not to disturb the fireflies' habitat, the segments were erected from an existing road using a crawler crane. Consequently, the assembly of formwork and steel reinforcements, the placement of concrete, and other work normally performed at the erection site could largely be performed at a separate location. As a result, the amount of work required at the erection site was greatly reduced, successfully minimizing the impact on the river environment (Photo 2, Figure 3). The erection of the main viaducts and Ramp D-3 are outlined below, together with a description of special approaches used in the cantilever erection of precast segments.



Photo2. Cantilever erection

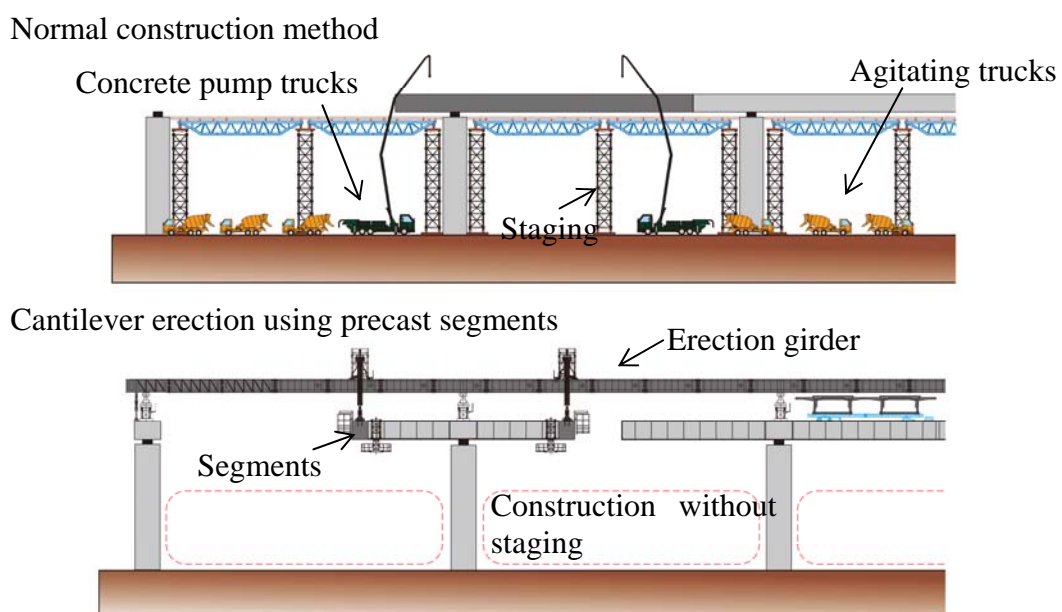


Figure 3. Comparison of construction methods

3.1. Outline of Main Viaduct Erection

The steps used in erection of the main viaducts are shown in Figure 4. The pier head is constructed first as a cast-in-place unit. The segments are then cast in a casting yard established on the earthworks area behind abutment A2, transported along the surface of the viaduct on trolleys (Photo 3), and then erected using erection girder (Photo 4). The weight of the erection girder was about 420 t. This approach enabled the elimination of temporary piers and large staging in the vicinity of the river, minimizing the impact of construction on the river environment. The cantilever construction was performed using core segments so that PC panels could be laid directly onto ribs after erection, and cast-in-place concrete then placed on the panels, producing a prestressed concrete panel composite slab structure (Figure 5, Photo 5). This prestressed concrete panel composite slab structure was adopted for the purpose of reducing the weight of segments, and also allowed smaller equipment to be used for segment casting and transportation. Reducing the size of equipment kept the impact on the river environment to a minimum, too, and was economical, as the cost of the erection process was similar to the cost of erection using staging.

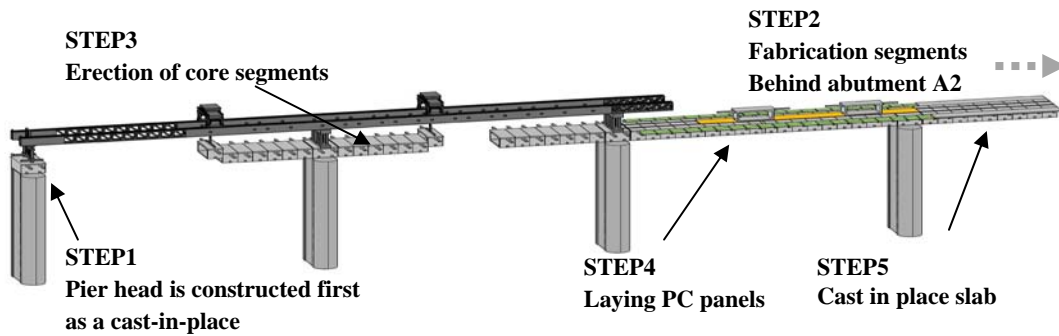


Figure 4. Construction step of main viaduct erection



Photo3. Transport segments



Photo 4. Cantilever erection

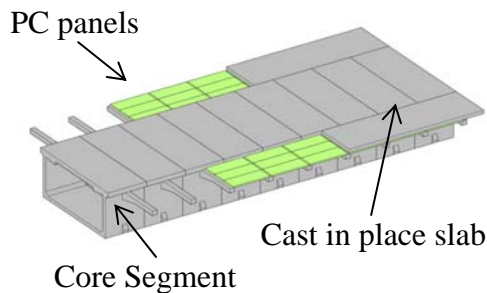


Figure 5. Composite slab structure



Photo 5. Construction of cast in place slab

3.2. Outline of Ramp D-3 Erection

Ramp D-3 runs alongside the Matoba River, so a precast segment construction method like that for the main viaducts was used in order to minimize impact on the river environment. To avoid impact on the firefly habitat, erection work on the area immediately adjacent to the Matoba River was paused from March to June when the fireflies are active on land.

The steps used in erection of Ramp D-3 are shown in Figure 6. The pier head is constructed first as a cast-in-place unit using full staging. The segments are then cast in a casting yard established on the earthworks area behind abutment A2, transported along a public road on a low bed trailer (Photo 6), and then erected using a crawler crane (Photo 7). The segments were erected using cantilever erection for piers P1 - P4, and full staging for the side spans at abutments A1, A2, which are located away from the river. The initial plans called for erection using full stagings, but this approach greatly reduced the need to install stagings close to the river.

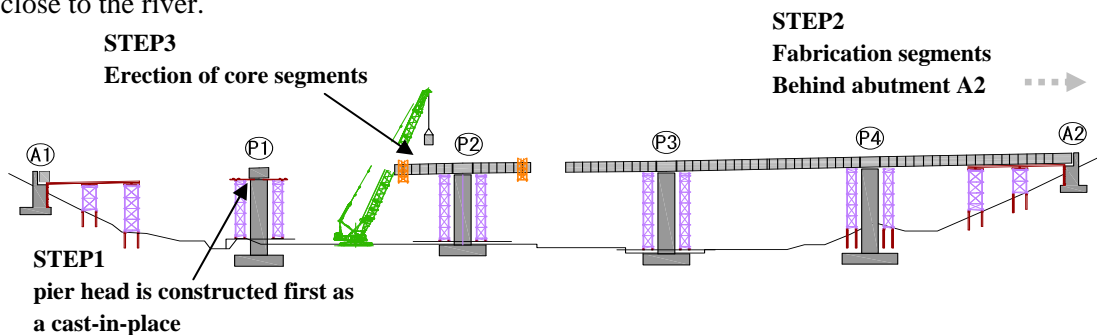


Figure 6. Construction step of Ramp D-3 erection



Photo 6. Transport by low-floor trailer



Photo 7. Erection using crawler crane

4. FABRICATION SEGMENTS

The segments were fabricated by casting using a short line match cast method in a casting yard set up on the earthworks area behind abutment A2. (Photo 8). Short line match casting method is a method of fabricating a NEW segment by using OLD segment used as a formwork (Photo 9, Figure 7). Three units were used casting the segments. These beds were used to cast 148 segments for the Up line and 138 segments for the Down line and 110 segments for the Ramp D-3, with the largest segments weighing 43 t.

Waste water from the segment casting yard, including curing water, was treated before discharge to neutralize it and adjust turbidity using a turbid water treatment unit (Photo 10) set up in the yard.



Photo 8. Fabrication yard



Photo 9. Short-line-match-cast method

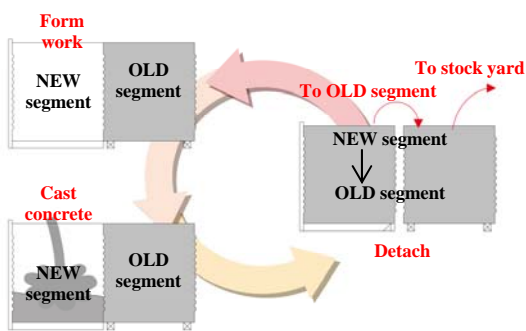


Figure 7. Short-line-match-cast method



Photo 10. Water treatment unit

5. TENDONS WITH ULTRA-HIGH STRENGTH STRANDS USED FOR EXTERNAL TENDONS

For the external tendons, 19S15.7 epoxy-coated tendons with ultra-high strength strands were used (Photo11). Using tendons with ultra-high strength strands gave breaking loads and yield point loads that were approximately 28% higher than those for conventional 19S15.2 tendons, enabling the structure to be designed with fewer tendons. Segment weight could be reduced, and it became possible to leave space within the girder for maintenance access (Photo12). The use of stronger tendons also reduces the weight of tendons, which contributes to reducing CO₂ emissions at the manufacturing stage.

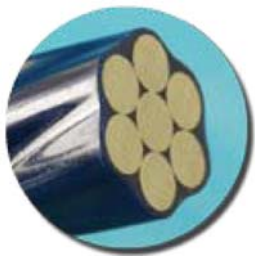


Photo 11. Epoxy-coated tendons with ultra-high strength



Photo 12. External tendons layout

6. CONSERVATION OF FIREFLY HABITANT DURING ONSTRUCTION

Adopting a precast segment construction method freed up space below the viaduct, which was used to construct a firefly biotope (Photo 13, 14). River improvement work has changed the cross-section of the Matoba River, and the sandbanks and similar places that provide a habitat where firefly larvae can hatch are now often inundated when the level of water in the river rises. The biotope was designed to provide an additional riverside area for the fireflies to lay their eggs. It was designed by Prof. Yamada of Fuji Tokoha University, providing a total of 45 m of restored river environment with rocks, trees, and grass. The water flowing through the biotope is provided by gravity feed to ensure the permanence of the facility. To check the impact of construction on the firefly habitat, and in February 2011 we confirmed the presence of firefly larvae in the biotope (Photo 15)



Photo 13. Over view of biotope



Photo 14. Erection girder and biotope



Photo 15. Firefly larvae



Photo 16. The gleaming of fireflies

We performed surveys of the habitat. The surveys included three larval surveys, Adult fireflies were also surveyed three times, confirming that the number of fireflies has been sustained (Photo 16, 17). Additionally, viaduct piers adjacent to the Matoba River have been greened, with plantings under the piers to conserve the firefly habitat (Photo 18).



Photo 17. Survey of firefly habitat



Photo 18. Plantings under the piers

7. ACTIVITIES TO RAISE AWARENESS OF THE ENVIROMENT

During the construction period Central Nippon Expressway Company collaborated with local residents' associations and other groups to raise awareness of environmental conservation. In June each year we organized firefly watching events and nature study sessions (Photo19, 20). The nature study sessions involved local residents and children from the local elementary and junior high schools. Led by students from Fuji Tokoha University, they included nature games and nature play focusing on plants and grasses. The aim was to enhance participants' environmental awareness by learning about the wonders of the natural environment in the neighborhood. These activities were covered several times by the local newspaper, so also functioned as a means of communicating the company's work on environmental conservation. We also took active part in local activities such as regular grass-cutting and clean-up sessions along the Matoba River.



Photo 19. Firefly watching events



Photo 20. Nature study sessions

8. CONCLUSIONS

Construction of this viaduct required conservation of the Matoba River environment and a short construction term. Selecting cantilever erection with precast segments as the construction method enabled the load on the environment to be minimized.

Through this project, many new ideas were tried in order to take conservation of the environment into consideration in construction. By efforts to maintain the Matoba river environment during construction, the habitat of fireflies was able to be sustained. In addition, by placing the biotope, we could expand the habitat of fireflies. In addition, We told the younger generation the importance of the natural environment of the region, We would like to hope that the environment will be maintained in the future.

Meeting the local residents who collaborated in the environmental activities was particularly beneficial for gaining local understanding of the construction project. As a result, we were able to successfully complete the project in August 2011 without affecting the habit of the Matoba River fireflies.

We hope that this paper will be of use for planning future bridges with consideration for the environment.

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