Development of Non-Metal Bridge Contributed High Durability

Yasuo FUKUNAGA
Manager
West Nippon Expressway
Osaka, Japan
y.fukunaga.aa@w-nexco.co.jp

Takeshi OHSHIRO
Civil Engineer
West Nippon Expressway
Osaka, Japan
t.oshiro.aa@w-nexco.co.jp

Takayuki MATSUI
Civil Engineer
West Nippon Expressway
Osaka, Japan
t.matsui.ab@w-nexco.co.jp

Akio KASUGA
Director
Sumitomo Mitsui Construction
Tokyo, Japan
akasuga@smcon.co.jp

Hiroshi ASAI
Civil Engineer
Sumitomo Mitsui Construction
Tokyo, Japan
h-asai@smcon.co.jp

Naoki NAGAMOTO
Civil Engineer
Sumitomo Mitsui Construction
Tokyo, Japan
nagamoton@smcon.co.jp

Summary

Maintenance becomes increasingly important as infrastructure plays a growing role in society, and there is consequently a need to enhance the durability of concrete bridges in order to reduce future maintenance costs. Considering these circumstances, the authors developed a Non-metal bridge that completely eliminates the use of steel members such as steel reinforcements and prestressing steel. We began by using aramid FRP rods as prestressing tendons to provide tensile force reinforcement. To eliminate the need for shear reinforcement, we also developed a high strength fiber reinforced concrete with high shear strength. That structure was conducted by wheel load running tests to verify the fatigue durability. After that, a half scale butterfly girder structure was built by using segmental method and tested to confirm that the structure of the joints between segments was sufficiently durable.

Keywords: Non-Metal Bridge; High strength fiber reinforced concrete; Aramid FRP rod; Minimum maintenances; Fatigue durability.

1. Outline of Non-Metal Bridge

The non-metal bridge is a concrete structure utilizing high strength fiber reinforced concrete (*Fig. 1 and 2*). Tensile stress produced by bending moments and axial tensile force is countered by reinforcement using aramid FRP rods for tendons, completely eliminating the use of prestressing steel and steel reinforcements. The concrete used is reinforced with high-strength steel fibers to enhance shear strength. This enables the elimination of the shear reinforcement (stirrups) used in ordinary concrete bridges. For beam bridges, the web is assumed to have a butterfly web structure that utilizes butterfly-shaped concrete panels to reduce weight and rationalize shear reinforcement. The erection process for the proposed bridge assumes that precast segments are fabricated at a precast plant, then transported to the erection site, where they are joined. This process raises quality and reduces labor requirements at the site.

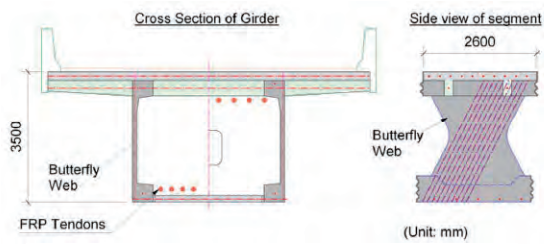

Fig.2: Out view of the segment for Non-Metal

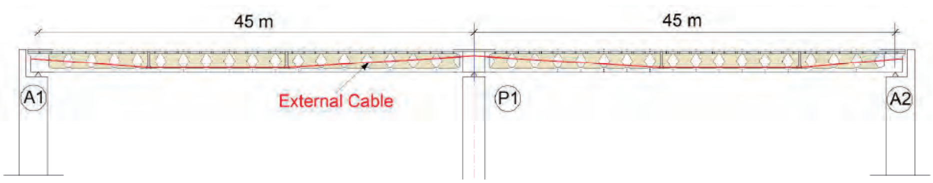

Fig.1: Side view of Non-Metal Bridge

2. Development of High Strength Fiber reinforced Concrete

The concrete used for the non-metal bridge needs to have high compressive strength and shear load capacity. For this reason the design strength for compressive strength was specified as 80 MPa.

Adding 0.5% of high strength steel fibers to concrete with a water-binder ratio of 25% produced a concrete with compressive strength of 80 MPa and shear strength of 17 MPa. By using this concrete, it is possible to attain the required performance for butterfly panels. And shear experiments on beams using this concrete show that adding the steel fibers has the effect of raising diagonal tensile fracture strength by a factor of 1.6.

3. Investigation of Fatigue Durability of Upper Deck Slab

The upper deck of a road bridge has a high probability of manifesting fatigue damage due to heavy traffic. The upper deck structure of the proposed bridge has none of the steel reinforcements or prestressing steel used to reinforce an ordinary concrete deck slab. Instead, the structure of the deck slab incorporates ribs made of high strength fiber reinforced concrete, and is reinforced by tension applied using aramid FRP rods. As described above, it also com-prises precast segments joined at the site, so its overall structure is very different from that of an ordinary concrete deck slab. The experiments were performed on this deck and ribs structure, investing fatigue durability with a wheel load running test on a full size specimen, focusing on the deck slab with ribs and on the joints between precast members (*Fig. 3*).

The results of testing confirmed that fatigue performance was sufficient for 100 years of service with traffic levels equivalent to a heavy traffic route in Japan (*Fig. 4*).

Fig.3: Wheel load running test in progress

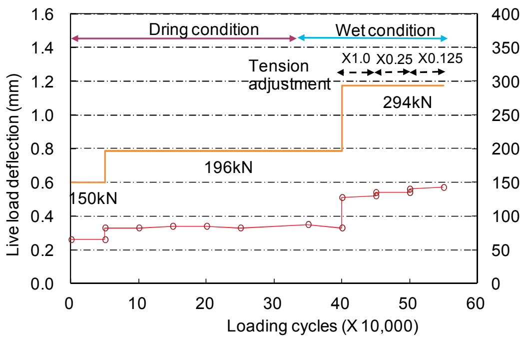

Fig. 4: Result of wheel load running test

4. Investigating Shear Capacity of Proposed Structure

The proposed structure uses the butterfly panels and the concrete itself to resist shear. In particular, as the bridge is designed on the assumption of construction using precast segment structures, the joints between such segments are only continuous at the upper deck and lower deck, so stresses are likely to concentrate at these locations. For this reason, shear behavior was investigated using the cantilevered beam test specimen shown in *Fig. 5*.

It was confirmed that the joints between segments have performance that can resist shear by means of the newly-developed high strength fiber reinforced concrete alone. The ordinary design method for diagonal tension failure can be used.

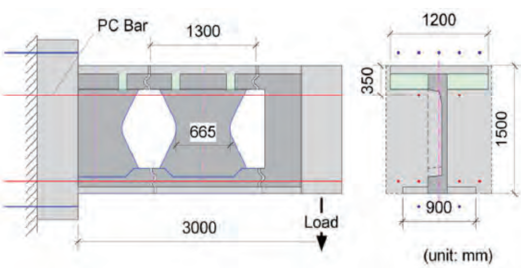

Fig. 5: Outline of segment shear capacity test