Prestressed Concrete Bridge Using Ultra-high-strength Fiber-reinforced Concrete Cast-in-place Method Ultra-high-strength — Kotaki River Bridge —

「場所打ち UFC による PC 道路橋」の概要
— デンカ小滝川橋 —

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Keywords: ultra-high-strength fiber-reinforced concrete, UFC, PC bridge, cast in place
DOI: 10.11474/JPCI.NR.2018.149

1. Introduction

Ultra-high-strength fiber-reinforced concrete (UFC)[1], which typically has a compressive strength of at least 150N/mm^2 and tensile strength of at least 5N/mm^2, brings a great deal of flexibility and additional value to design and construction, including reduction in weight and increase of long-term durability of members, through such excellent material characteristics as high strength, high toughness, and high durability. UFC has been used mainly for precast products manufactured in factories equipped with heat-curing facilities to utilize its high performance. However, depending on the scale and conditions of construction, a cast-in-place method may be more rational.

Fig.1 Completed Kotaki River Bridge

Under such circumstances, the construction of the whole structure of an actual bridge using the UFC cast-in-place method was implemented for the first time in Japan. This paper reports the results of experiments and construction aimed at establishing a cast-in-place construction method. The completed bridge is shown in **Fig.1**.

This bridge was honored with the technology development Award of the Japan Prestressed Concrete Institute in 2014.

2. Application of Cast-in-place Method

(1) Outline of Construction

The bridge was constructed to replace a 100-year-old suspension bridge with a girder bridge made of AFt-UFC [2] because of the renewal of a private electric power facility. The new bridge was designed as a post-tensioned simple prestressed concrete (PC) T-girder bridge with a bridge length of 39.0m, girder length of 38.8m, and total width of 5.2m (with a frame volume of about 90m^3). Given that it would be constructed at a location where salt damage due to the use of deicing salt and freeze/thaw damage are expected, UFC was selected to reduce the maintenance cost. **Fig.2** shows a perspective drawing of the structure.

(2) Design and Specifications

Table-1 gives the characteristic values and limiting stress values of the material used in the design.

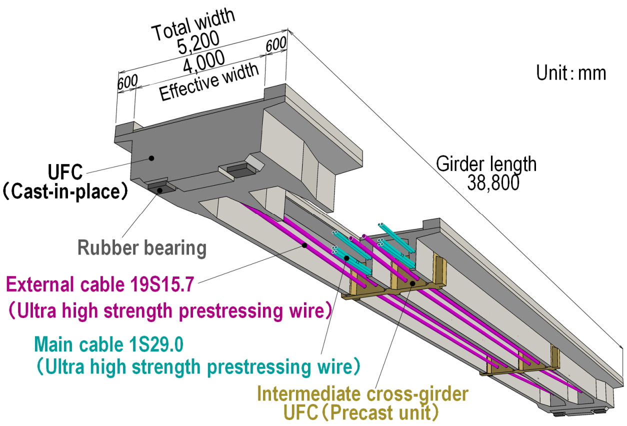

Fig.2 Perspective drawing

As described above, this bridge was basically constructed of cast-in-place UFC. However, it was found that significant tensile stress occurred at the intermediate cross-girder portion in the direction perpendicular to the lower edge of the main girder. This was due to the axial compressive force toward the lower edge that acts during maximum prestressing of external cable. Therefore, by having only the intermediate cross girder as a precast unit expected a higher tensile strength, the structure was made as resistant as possible against local stress (**Fig.2**). This allowed the intermediate cross girder to be the placing boundary, enabled continuous construction of a component with a total length of 30m by dividing it into three parts, and helped solve construction issues including resolution of vertical overlays and reduction of UFC flow distances.

Table-1 Design and characteristic values of UFC

Items (unit: N/mm²)		Cast-in-place	Precast
Compressive strength	f'_{ck}	150	180
Allowable bending compressive unit stress	$0.6f'_{ck}$	90	108
Cracking strength	f_{crk}	4.0	8.0
Tensile strength	f_{tk}	6.5	8.8

Precast: Characteristic values of UFC (steam curing)

(3) Construction

Fig.3 shows the construction situations of UFC. The end cross girder was mass concrete and there was a risk of thermal cracking. Therefore, the maximum temperature in the central part was suppressed by pipe cooling using river water at 5°C. Meanwhile, the whole work area was covered with unit-type curing panels and double-ply fireproof sheets, and the air temperature after placement was maintained at 30°C by using heat-exchange-type hot-air machines. In particular, to ensure strength development at thin parts where less self-heating occurs than at other parts, the temperature of the members was maintained at 30°C or above for 48 h after placement (**Fig.4**).

As a result, the strength of the specimens that were cured together with the member on the thin part (floor-

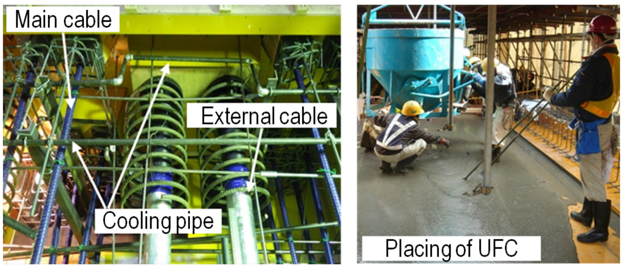

Fig.3 Construction situations of UFC

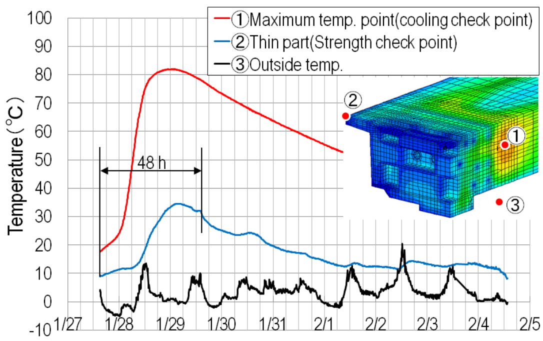

Fig.4 Results of temperature measurements

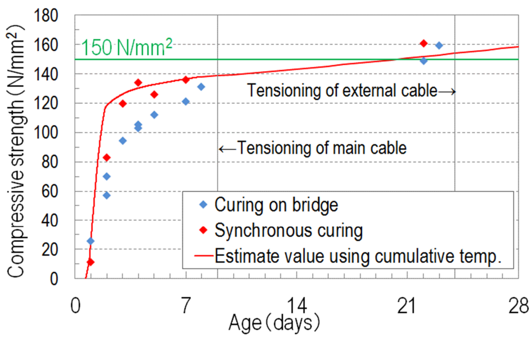

Fig.5 Results of compressive strength on site

slab edge overhang) reached the target strength of 150N/mm² at a material age of 22d from placement (**Fig.5**).

3. Conclusion

For the construction of the Kotaki River bridge, which was implemented by applying cast-in-place UFC for the first time in Japan, various studies were conducted of the cast-in-place method. The study results were reflected in the construction, and excellent results were attained. It is expected that cast-in-place UFC will be used increasingly not only in new construction but also for repair and reinforcement. We hope that this report will prove to be helpful in such construction.

References

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