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Autor: Itohiya, T. / Tokunaga, G. / Iriya, K.

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Prevention of Thermal Cracking in the Anchorage of the Akashi Kaikyo Bridge

T. ITOHIYA
Honshu Shikoku Bridge Authority
Tokyo, Japan

G. TOKUNAGA
Honshu Shikoku Bridge Authority
Kobe, Japan

K. IRIYA
Obayashi Co.
Civil Eng. Div.
Tokyo, Japan

C. SHINKAI
Obayashi Co.
Civil Eng. Div.
Osaka, Japan

S.SOGO
Obayashi Co.
Technical Institute
Tokyo, Japan

Summary

The Akashi Kaikyou Bridge will be the longest bridge in the world in 1998 after completion, which length is 3,990m and center span is 1,990m. The understructures consist of a couple of anchorage and foundation of towers. A large volume of concrete , which is approx. 140,000m^3, is needed for the each anchorage (1A and 4A) to resist the designed force. Construction method of such massive concrete is usually constrained by thermal stress due to heat of hydration causing severe cracking. In addition to the volume, rapid construction was required. Several new methods have been developed and applied to fulfil the requirements, such as low heat cement, pre-cooling, pipe cooling and highly workable concrete. The process of applying these new methods and results of the construction were described in this paper.

1. Procedure of selecting construction method of 1A

Remarkable requirements of constructing 1A anchorage of the Akashi Kaikyo Bridge are to solve problems of the cracking and rapid construction, which has to place approx.140,000m^3 of concrete during 28month including setting anchor-frame and many steel structures. Since the horizontal area is 5500m^2 and the height is 47.5m, whole volume of concrete can't be placed at once and it has to be divided into several blocks and lifts. Area of a block was decided to take the length of the anchor-frame into account, and height of a lift was planed to take thermal crack index and total period of concreting into account. Planned area of blocks and lift schedule are shown in Fig.1 and 2. Method of preventing cracking was designed based on "the design standard on cracking due to thermal stress for

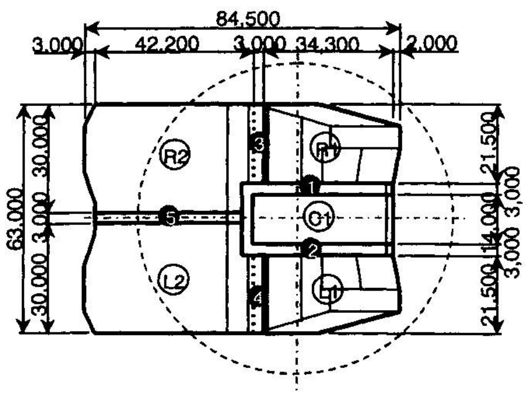

Fig.1 Planned Blocks for Construction

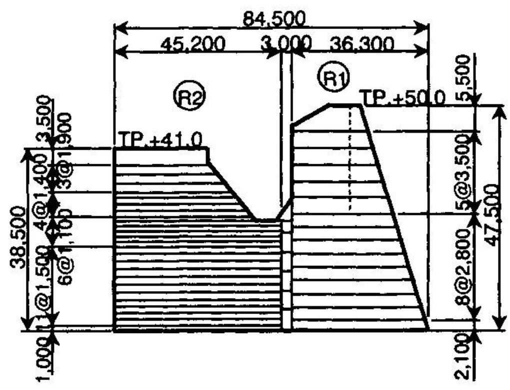

Fig.2 Planned Lifts for Construction

massive concrete in bridges", which was authorized by Honshu Shikoku bridge authority. Thermal stress was calculated by FEM for candidates of construction methods and thermal crack index (strength/calculated thermal stress) was assessed for each case. The most suitable method by considering the value and economic effects were decided to fulfil the above value. The lowest designed thermal crack index was 1.2, which means to allow small cracking but to prevent severe one. Concrete temperature, cooling method, and height of a lift were planned to fulfil this limit.

2. Construction method of 1A for prevention of cracking

The following methods were adopted for actual construction to prevent cracking.

1) Low heat cement, in which large portion of Portland cement was replaced to possolan, such as fly ash and blast furnace slag, was developed and applied. Adiabatic rising temperature of the concrete with 260kg/m^3 of cement was less than 25℃. Calcium carbonate was adopted as powder to achieve self-filling property without heat generation.
2) The new type of concrete mixing plant with two mixers which capacity were each 6m^3 was constructed, where water chiller and ice plant making flake ice were attached.
3) Pipe cooling by chilled water and pre-cooling by flaked ice was adopted for whole concrete and placing temperature of all concrete was less than 20 ℃.
4) Special pre-cooling with liquid nitrogen was temporary adapted to support the above mentioned pre-cooling. It was applied for upper part of concrete placed in summer where 15℃ was required due to excessive height to 3m.
5) Since 3m width of slot were stetted at the side of next block, individual concreting schedule could be planed without constraint of the next block. It decreased the period of concreteing.

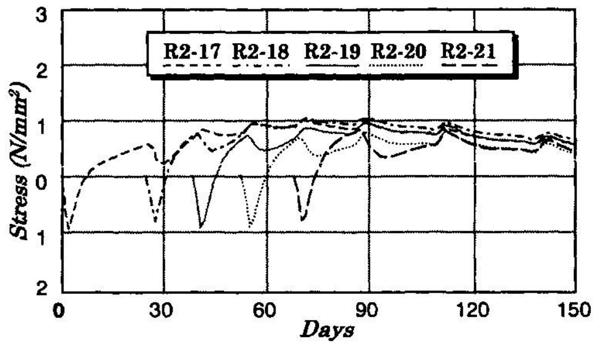

Fig.3 Measured Stress

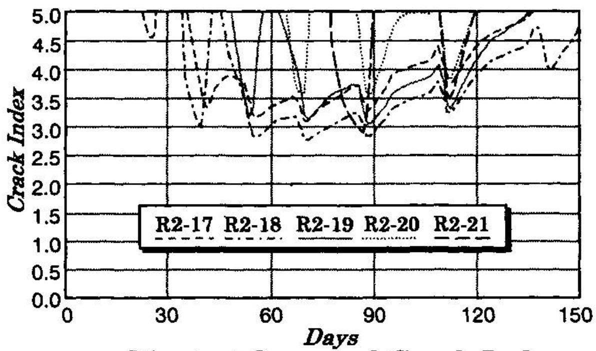

Fig.4 Measured Crack Index

3. Results of the construction

The stress and crack index in the center of continuous several lifts, which were concreted in high atmospheric temperature, was shown in Fig.3,4. The temperature was measured less than 38 ℃ and the maximum generated tensile stress was about 1.0 N/mm^2. This indicated that little risk of cracking was existed during construction. After the temperature reached 16℃ 3m widths of slot were finally filled with concrete, and the concreting work was completely finished until 1996.4. Both rapid construction and control of cracking were satisfied in this construction of 1A anchorage.