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Autor: Toyofuku, T. / Meta, T. / Inokuma, Y.

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NIHON DORO KODAN

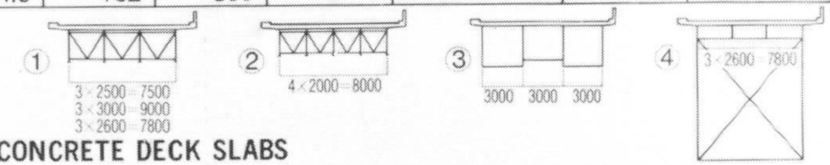
J APAN
H IGHWAY
P UBLIC
C ORPORATION

APPLICATION OF EXPANSIVE CONCRETE TO REINFORCED CONCRETE DECK SLAB

BRIDGES APPLIED OF EXPANSIVE CONCRETE

No.	NAME OF BR.	CROSS SECTION TYPE	THICKNESS OF DECK SLAB (cm)	DESIGN STRENGTH OF CONCRETE (kgf/cm^2)	SPECIFIED MIX (kgf/m^3) $\frac{w}{c+e}$ (%)	WATER CONTENT w	CEMENT CONTENT c	CONTENT OF EXPANSIVE AGENT e	MAXIMUM AMOUNT OF EXPANSION OF REINFORCED CONCRETE DECK SLAB ($\times 10^{-6}$) AMOUNT OF EXPANSION TESTED BY JIS A 6202	TRANSVERSE DIRECTION	LONGITUDINAL DIRECTION
1	KUROISHIHAMA BR.	①	24	300	41.2	160	345	35	320	267	190
			24	300	41.2	160	380	—	—	—	—
2	TARAMI BR.	②	21	240	50.3	161	285	35	253	215	156
			21	240	50.3	161	320	—	—	—	—
3	KOSUGE BR.	①	24	240	47.0	141	265	35	257	163	123
			24	240	47.0	141	300	—	—	—	—
		③	24	240	47.0	141	265	35	303	49	70
			24	240	47.0	141	300	—	—	—	—
4	KURINOKI-RIVER BR.	④	23	240	56.4	172	260	45	425	240	200
			23	240	57.3	172	300	—	—	—	—
5	MARUKI BR.	①	23	240	54.7	164	265	35	220	143	88
			23	240	54.0	162	300	—	—	—	—

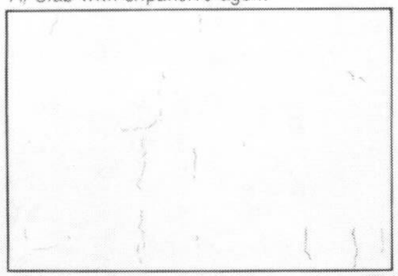
Upper side; Reinforced concrete with expansive agent
Lower side; Reinforced concrete without expansive agent



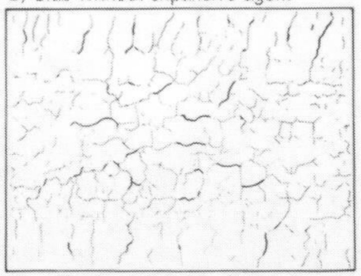
CRACKING ON BOTTOM SURFACE OF REINFORCED CONCRETE DECK SLABS

No.1 KUROISHIHAMA BR. (After 58 months)

A) Slab with expansive agent

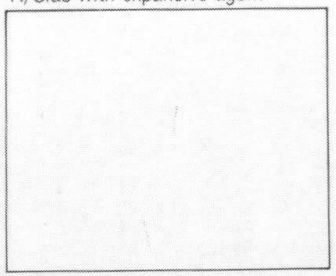


B) Slab without expansive agent

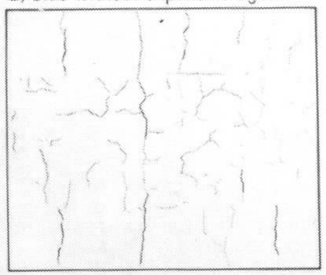


No.2 TARAMI BR. (After 38 months)

A) Slab with expansive agent



B) Slab without expansive agent



Thin line: Crack width 0.05mm or less / Thick line: Crack width 0.05 ~ 0.15mm

Application of Expansive Concrete to Reinforced Concrete Deck Slab

T. TOYOFUKU
Nihon Doro Kodan
Tokyo, Japan

T. META
Nihon Doro Kodan
Tokyo, Japan

Y. INOKUMA
Nihon Doro Kodan
Tokyo, Japan

1. Introduction

The deterioration process of reinforced concrete deck slab in steel road bridge can be explained as follows, according to loading test and survey on the existing bridges by Nihon Doro Kodan.

(1) Initial cracking due to drying shrinkage,subsidence, thermal stress and all that.
(2) Crack extention from top to bottom surface due to drying shrinkage
(3) Rain water infiltration into cracking zone.
(4) Abrasive action between crack surface by cyclic wheel loading and accelerating abrasion due to existence of water.
(5) Decrease of shear capacity.

Therefore, it is effective for the increase of durability of reinforced concrete deck slab to prevent initial cracking. Nihon Doro Kodan has applied experimentally expansive concrete to reinforced concrete deck slab of steel bridges shown in Table-1 since 1980 in order to cope with initial cracking.
Prior to the application, testing was conducted to know the influence of kinds and quantity of expansive agent on amount of expansion and compressive strength of concrete. And the observation is being made to know the difference of cracking behavior, temperature, strain variation caused by bridge types and meteorological condition.

2. Mixing

The specified mix is shown in Table. In case of expansive concrete, 35 kg/m of cement content in normal concrete was replaced by expansive agent, for it was found out by testing that the same compressive strength as normal concrete is obtained by the replacement while amount of expansion increase in proportion to content of expansive agent. But,the compressive strength of concrete tends to decrease when content of expansive agent exceeds 35 kg/m^3. The reason why expansive agent of 45 kg/m^3 was replaced in Kurinoki-River bridge was not only to reduce initial cracking, but to induce higher chemical prestress to concrete. And cement content of 5 kg/m^3 was added to compensate the decrease of compressive strength of concrete.

Table-1 Bridge Type

Name of Bridge	Type of Bridge	Bridge Length (m)	Compressive Strength of Concrete at the age of 28 days (kgf/cm^2)
Kuroishihama Bridge	Simple Composite Steel Plate Girder	41.5	446 384
Tarami Bridge	4-span Continuous Non-Composite Steel Plate Girder	149.2	331 335
Kosuge Bridge	2-span Continuous Non-Composite Steel Plate Girder	46.5	343 310
	3-span Continuous Non-Composite Steel Box Girder	157.0	344 344
Kurinoki-River Bridge	3-span Continuous Steel Truss	265.7	312 310
Maruki Bridge	4-span Continuous Non-Composite Steel Plate Girder	170.0	281 317

Upper Side : Expansive Concrete
Lower Side : Normal Concrete

3. Expansion

Amount of expansion shown in Table is the elongation of reinforcing steel bars in reinforced concrete deck slabs. Amount of expansion in transverse direction are larger than that in longitudinal direction. As the box girder bridge has higher flexual stiffness compared with that of other bridges, amount of expansion of box girder in Kosuge bridge is smaller than that of other bridges.
It was clalified that amount of expansion differs by the direction and the type of of bridges.

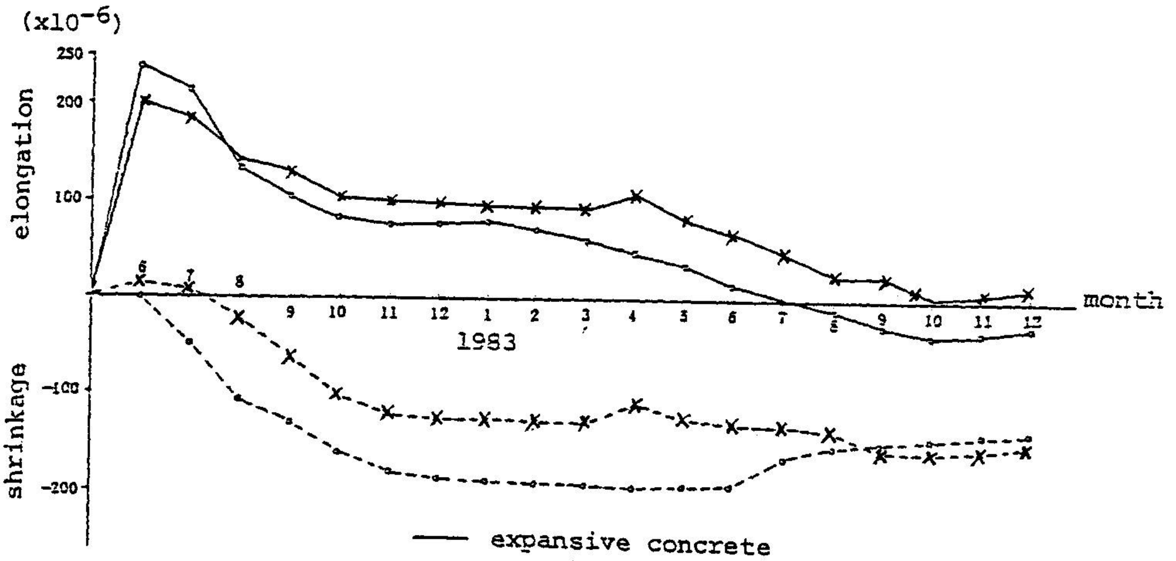


Fig-1 Time-dependent strain variation of reinforcing bar of deck slab in transverse direction.

4. Cracking

As shown in Table which describes the cracking on bottom surface of deck slabs of Kuroishihama and Tarami bridge, cracking in case of expansive concrete is remarkably little in comparison with that of normal concrete. This phenomenon was observed in other bridges as well.

Fig-1 shows the time-dependent strain variation of reinforcing steel bars in normal and expansive concrete deck slab of Tarami bridge.

In case of expansive concrete, maximum amount of expansion was 250×10^{-6}, but expansion was compensated by drying shrinkage of concrete after ayear. On the other hand, in case of normal concrete, drying shrinkage of 200×10^{-6} occurs and tends to crack. The difference of cracking between normal and expansive concrete can be proved by this time-dependent strain variation.

It was confirmed that a good effect in prevention of initial cracking by use of expansive concrete can be expected.