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Nihon Doro Kodan's Bridge Maintenance System

Programme d'entretien de ponts-routes au Japon

Brückeninstandhaltungs-Kontrollsystem in Japan

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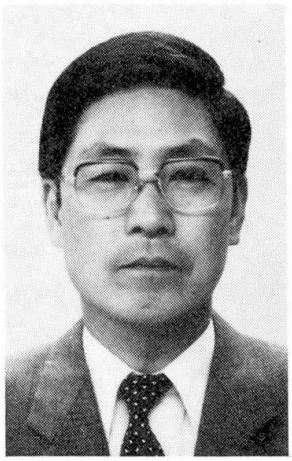

Born in 1935, graduate from Waseda Univ., Faculty of Civil Engineering Civil Engineer for planning design and supervision of Highway Projects at Nihon Doro Kodan for 25 years. Expert on large scale prestressed concrete bridge design and construction.

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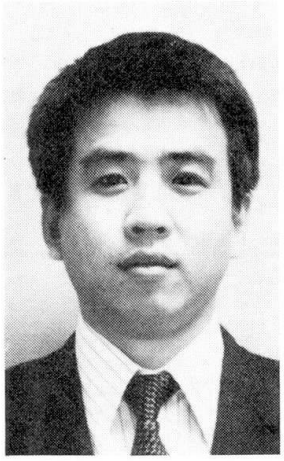

Born in 1951, graduate from Nihon Univ., Faculty of Civil Engineering Participated in the construction and administration of Express Highways for 9 years at Nihon Doro Kodan. Presently engaged in the inspection and repair services of bridges.

SUMMARY

The bridge maintenance system of Nihon Doro Kodan is introduced in this report. The maintenance and repairment works of bridge structures are one of the major maintenance works of the Japan's highway operations. The rating and repairment of damaged bridge decks are also explained as a main part of the above system.

RESUME

Le rapport présente le programme d'entretien des ponts dans le réseau japonais d'autoroutes. Les travaux d'entretien et de réparation des structures de ponts font partie des travaux essentiels pour l'exploitation efficace du réseau autoroutier. L'évaluation et la réparation des tabliers de ponts endommagés font également partie de ce programme.

ZUSAMMENFASSUNG

Der Bericht behandelt das Brückenunterhalt-Programm im japanischen Autobahnnetz. Die Unterhalt- und Instandstellungsarbeiten an Brücken sind ein wichtiger Bestandteil für eine wirksame Nutzung des Autobahnnetzes. Die Schätzung und Instandstellung der beschädigten Brückenbeläge sind in diesem Programm ebenfalls enthalten.

1. PREFACE

Japan has a plan for an Express Highway Network of 7,600 km that covers all the areas of its territories. The construction of this expressway network had been entrusted to a single organization that is Nihon Doro Kodan. At the end of 1982, 3,111 km will be in operation and additional 2,738 km will be under construction. Among the portion which has been opened to traffic, the earthwork section, the tunnel section and the bridge section are 86.0%, 2.2% and 11.8% respectively.

During these 20 years since the expressway was opened the deterioration of the expressway structures has become obvious. Accordingly the cost of maintenance and repairment has reached to about 260 million dollars (84,700 dollar/4 lanes.km) per year. The 11.7% of this total maintenance expenses, which is 30.5 million dollars (87,100 dollars/4 lanes.km), is spent for bridge structures. It is quite remarkable that 30% of the total bridge maintenance cost is allocated for the repairment of reinforced concrete bridge decks which are damaged seriously by the heavy traffic.

It is very important to find out in the earliest stage the signs of the damages in the bridge structures in order to take the necessary measures for the repairment. Nihon Doro Kodan is carrying out the inspection patrols under its "Bridge Maintenance System" which enables "the early findings and lower repairment costs".

2. OUTLINE OF THE BRIDGE MAINTENANCE SYSTEM

2.1 Record plan from the bridge inspection to the repairment

The flow diagram of the maintenance from the bridge inspection to repairment is shown in Fig. 1.

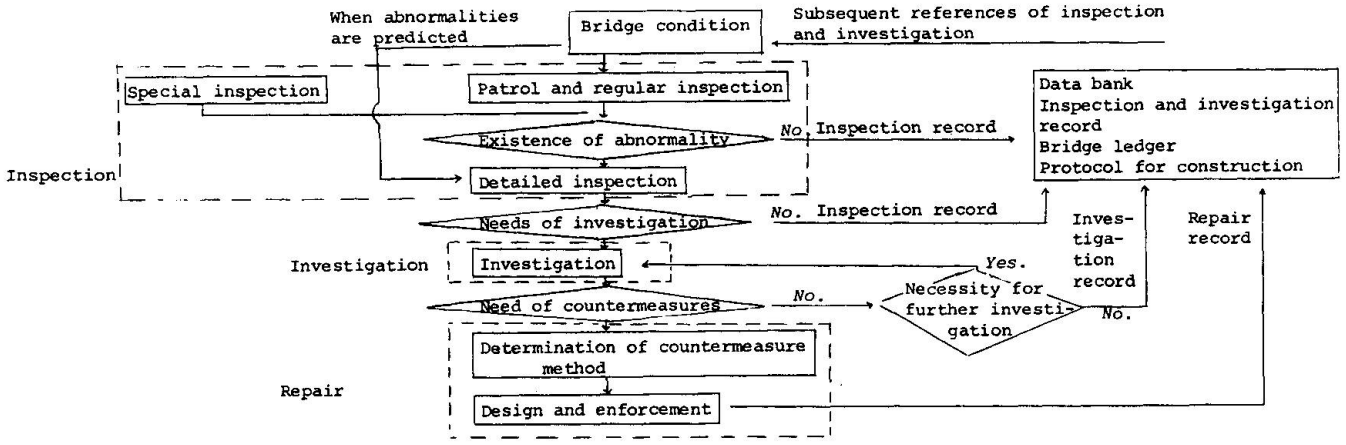

Figure 1. Flow diagram of inspection, investigation and repair works

2.2 Outline of bridge patrol, inspection and investigation

Actual conditions of the bridges are grasped through ordinary patrols, inspections, and investigations. The bridge maintenance works are carried out according to the degrees of its damages. The summary of this maintenance works are shown in Table 1.

2.3 Filing of records

The inspection results are summarized in a report paper; the construction record and the repairment history are written on the bridge ledger and these are put together in a micro film, stored in the data room. A photocopy from the originals are used in the regular administration. Shortly, together with the establishment of the Computer Center, the information transfer network that connects this Kodan's Head Office with the Operation Bureaus and offices will be developed. This network is utilized presently as an Information Control System that handles any kind and all sorts of information input or output, according to various demands.

	Item	Purpose	Method	Frequency	Personnel
1	Patrol	Early detection of abnormalities and damages in the upper surface of the brdige.	By patrol car; walking as occasion demands.	Once a day	2 persons
2	Regular inspection	Early detection of abnormalities and damages in the whole structure.	Approach to the bridge as near as possible while walking and direct visual inspection or using binoculars.	More than once a year	3 to 4 persons
3	Special inspection	Rapid grasp of bridge conditions in case of darthquakes	Walking or by patrol cars	As occasion demands	3 to 4 persons
4	Detailed inspection	Observe in detail the abnormal places detected during the patrol and inspection and decide the needs for an investigation.	Approach the subject place by means of inspection road, ladder, or construction scaffoldings and simple measure by visual inspection.	As occasion demands	3 to 4 persons
5	Investigation	Quantitative grasp of the degree of damages from the detailed inspection results and decide the needs of repairments.	Approach to the subject place by means of special constructed scaffoldings and by visual inspection, stripping off, measure, core testings.	As occasion demands	Required personnel

Table 1. Outline of bridge patrol,inspection and investigation

3. REINFORCED CONCRETE BRIDGE DECK INSPECTIONS

3.1 Regular inspections

Inspections of the bridge decks are carried out approaching as near as possible, by direct visual inspection or using binoculars for the following items; 1) cracks, 2) scaling off, 3) leakage of water and calciums, 4) reinforcement corrosions, 5) concrete construction joints, 6) cracks on the pavement. The inspections are recorded in the "Inspection and Investigation Record" regarding following items; 1) existence and location of cracks, 2) existence and location of damages other than cracks, 3) needs of a detailed inspections.

3.2 Detailed inspections

3.2.1 Purpose of the detailed inspection

The purpose of the detailed inspection is to judge the needs for an investigation, estimating the condition of the bridge deck damages and degradations by visual inspection and a simple measure, in case of detection of damages and degradations during the regular inspection.

3.2.2 Method of detailed inspection

Taking the deck panel (girder span x deck span) as a single unit, observation shall be carried out and recorded regarding the following items in order to estimate damages and degradations.

1) Sketch of main crack locations (cracks bigger than 0.1mm in width)
2) Condition of the production of scale out
3) Leakage of water and calciums
4) Condition of reinforcement corrosions
5) Condition of pavement's linear cracks and hexagonal cracks

3.2.3 Record of detailed inspection

The detailed inspection results are written in the "Inspection and Investigation Record" (Fig. 2) and the main points of the damage and degradation condition are recorded as illustrated in Table 2.

3.2.4 Criteria for damage ratings during the inspection

Based on the detailed inspection results, and using the rating criteria shown in Table 3, the rating of the damages in the inspection are made, taking the deck panel (girder span x deck span) as a single unit.

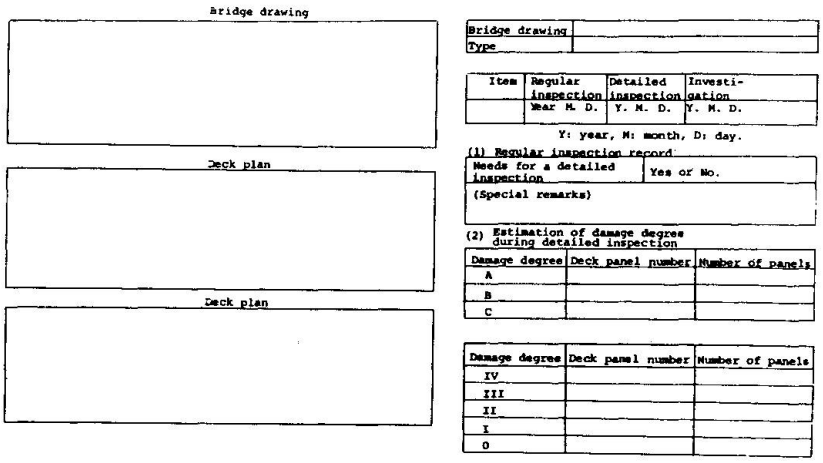

Fig. 2. Inspection and investigation record

Item	Indication method	Item	Indication method
Crack	Continuous lines	Leakage of water	R
Scaling out Abrasion	Continuous lines+dotted line	Calcium Separation	Y
Separation	H	Corrosion of reinforcement with openings	T
Hollows, poor cementations	M	Pavement cracks	one point dotted lines

Table 2. Classification of damages

Degree of damage	Floor system condition
A	Generation of bidirectional or hexagonal cracks. There are cracks in asuface portion of the pavement. Large generation of calcium separation.
B	Generation of unidirectional cracks, the crack spacing is more than 1 m. There are linear cracks in the pavement. Leakage of water and calcium separation found partly.
C	Generation of unidirectional cracks and crack spacing is more than 1 m. It is almost impossible to confirm the cracks.

Table 3. Criterion for estimating the degree of damage during the inspection (cracks larger than 0.1 mm in width)

4. INVESTIGATION OF THE REINFORCED CONCRETE BRIDGE DECK

4.1 Purpose of the investigation

In this detailed inspection, the deck panels estimated to have more than B rank of damage grade during the inspection (hereinafter called investigation panel) are investigated, the cracks are quantitatively comprised, and then the damage grade is estimated, including the conditions of damage and degradation other than cracks.

The procedure for making damage grade rating during the investigation is given below.

1) Confirm the location of main cracks sketched from the inspection results.
2) Determine the location of the places for measuring crack density of parts with remarkable crackings for each investigation panel.
3) Measure of crack density for cracks over 0.1mm in width, by the Grid Density Method.
4) Investigation of the condition of damage and degradation other than cracks, as occasion demands.
5) Rating of damage grade during the investigation.

4.2 Investigation of cracks

1) Draw a grid lines of 25cm in spacing on the decks bottom surface where the cracks are observed. Then from the number of crossing points, resulting from the intersection of the grid lines and cracks wider than 0.1mm, compute the crack density of the bridge's lateral direction (A) and the bridge's longitudinal direction (B). (Grid Density Method) Fig. 3.
2) Plot the crack density diagram as A/B and B/A ratio, and A+B (Fig. 4) for estimating the damage grade.

4.3 Investigation of damage other than cracks

1) Investigate the concrete's neutrality degree of the deck's inner part by using phenolphtalein.
2) Measure the natural period of oscillation and degree of deflection of the deck.
3) Measure the elastic modulus and strength of the concrete core by destructive tests.
4) Measure the crack depth by ultrasonic non-destructive tests.
5) Measure of crack depth by measuring the reinforcement strains.
6) Investigation of the upper surface of decks by removals of the bridge pavement.
7) Investigation of the pavements surfaces.

4.4 Criteria for damage ratings during the investigation

The criteria for damage ratings, as illustrated in Table 4, come from the crack density measured at the investigation.

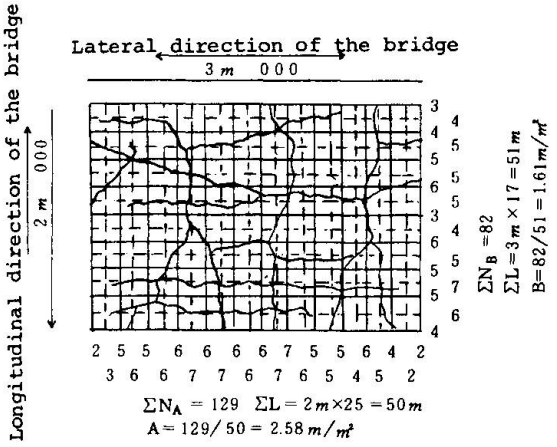

Fig 3. Example of crack density

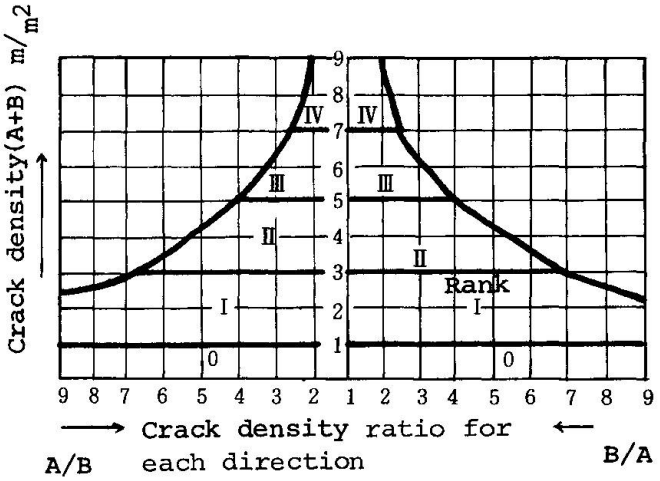

Fig. 4. Crack density diagram (For crack's width larger than 0.1mm)

5. REPAIRMENT PLAN OF REINFORCED CONCRETE BRIDGE DECKS

5.1 Repairment plan

According to the investigation results, the needs for a repairment plan are judged according to the deck damage conditions as follows;

Repairment plan

- Reinforcement: designed for increasing the decks load resistance capacity in order to avoid the crack's progress
- Water proofing: designed for water proofing of the cracked parts in order to avoid the crack's progress, concrete degradation, and reinforcement corrosions due to the penetration of water into the cracks.
- Prevention of concrete scaling out: designed for coating the floor system bottom surface in order to avoid scaling out of the concrete due to cracks.
- Replacement: complete removal of damaged decks and its replacement with new ones.

5.2 Rating of deck damages and repairment methods

The repairment methods of decks are decided from the estimation of damage degrees. It is necessary to select the proper repairment method according to the damage degrees and construction conditions.

The classification of repairment methods, according to the damage degrees is given in Table 5.

Damage of degree	Standard Crack density (m/m^2)	Average spancing (Reduced to bidirectional cracks)	Estimation of deck conditions
0	0 - 1.0 up to	200cm and more	Unidirectional cracks with spacing larger than 1m founded partly. The bidirectional crack density is still small and the load capacity of the deck is considered to be still high.
I	1.0 - 3.0 from to up to	200cm - 70cm	There is generation of unidirectional cracks, but the capacity as unidirectional slab is still expected
II	3.0 - 5.0 from to up to	70cm - 40cm	Generation of bidirectional cracks and the deck capacities decline in both directions. The leakage of water and the calcium separation are occasionally observed.
III	5.0 - 7.0 from to up to	40cm - 30cm	The bidirectional cracks develop with the crack corner's wearing and partly scaling out. The deck capacity drop remarkably in both directions. The leakage of water and the calcium separation become prominent. The cracks in the upper surface of the deck develop to produce concrete blocks.
IV	7.0 from to	30cm and less	The crack density reach the limit in both directions, and the load is supported almost only by the reinforcement grid effect, cracks are widened, and abrasion and calcium separation with muddy water are observed. When they progress, they cause holowing out and large scaling out. The damage of the upper surface of the deck is also progressed, and the pavement starts to peel off in some parts.

Table 4. Criterion for estimating the degree of damage during the investigation (cracks larger than 0.1 mm in width)

○ It is advisable to make countermeasures
◎ Problem in need of countermeasures

Degress of damage	Repair plan		Method of construction
Ⅰ Ⅱ Ⅲ Ⅳ	Rehabilitation measures		Stringer setting method, steel plate adhesion method, additional concreting method, spraying method, FRP method (concrete decks of steel and concrete bridges)
Ⅲ Ⅳ	Plan to avoid hollowing out		Steel plate ahdesion method, FRP method
Ⅳ	Replacement	Replacement of some parts	Resin concrete, super high-early concrete, Reinforced concrete deck.
		Total replacement	Steel deck, steel orthofropic deck
Ⅱ Ⅲ Ⅳ	Water proof plan		Resin grouting method, water proof sheet method

Table 5. Classification of repair method according to the degree of damages

6. FUTURE SUBJECT

As the bridge deteriorations proceeds with the passage of years, it is necessary to improve above-mentioned "Bridge Maintenance System" furthermore. It is also very important to clarify the bridge's deterioration mechanism through theoretical studies in order to establish the proper repairment methods. Further, the urgent needs are pointed out with regard to the development of automatic equipment for estimating the degree of soundness of the bridge structures and the systematic compilation measures of the inspection and investigation records.

REFERENCE

1) Main points for maintenance and repair (Compilation of Bridges and Floor Systems) Nihon Doro Kodan, 1973.