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A Method to Extract Scoured Bridge Piers

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It is essential for the maintenance of railway facilities to prevent bridge piers from susceptible scouring under flooded conditions. In this paper, the authors have proposed a method to extract the bridge piers for inspection. Railway bridge inspectors apply the foregoing method when bridge inspections take place. The method considers a change in the river environment adjacent to the bridge and pertinent factors.

Key Words : *scours, bridge piers, judgment for soundness*

1. Introduction

It is important to prevent a disaster due to scouring around piers of Railway Bridge under flood conditions for the maintenance of railway structures. Therefore, it is necessary to extract the bridge piers where we are afraid of scouring from many bridges. Railway company must take sufficient measures when they find bridges are in danger. Japan Railways (JR) do "general inspections" in every two years, they examine the need of the repair. The JR performs "Individual inspection" later to bridge judged in danger by the general inspection. The inspector who belongs to the railway company does detailed bridge inspection, and the company maintains these bridges safely with this countermeasure.

Railway Technical Research Institute (RTRI) made a graded table to extract bridges in danger whose level will be high. This graded table was developed for the general inspection. The inspector of the railway company does a general investigation by using this graded table. They can judge whether bridges are in the risk or not by this inspection. Therefore, they often use this graded table.

The inspectors verify bridges judged in danger with general inspection with individual inspection. Not all bridges that are extracted with general inspection are dangerous. Thus, the inspector must extract bridges in danger by the individual inspection. It is insufficient to do a precise extraction as an actual problem only by the above the graded table made for the general inspection to do a precise extraction as an actual problem. Thus, detailed investigation is necessary. The individual conditions of the bridge influence each bridge in flood conditions. Therefore, the change in the river environment around the bridge should be considered. RTRI developed the way of extracting it including a change in a river environment. An inspector uses this way of extracting it at the time of the individual inspection.

2. The Method to Inspect Railroad Bridges

Railway Companies maintain structures to ensure demanded performance. They must secure bridges from scour around bridge piers. Thus, Railway company regularly checks the structures, and does detailed inspections if they are necessary in the period of structure use. They must repair the structure, if it is necessary as the result of this inspection. They make a record after repair. The following, the case of JR are mentioned. They do the general inspection concretely every two year through the period of the structure use. Bridges are investigated mainly with general inspections by the visual observation. As a result of the general inspection, they do separately an individual inspection to the necessary structures as detailed one.

Table 1 shows the relations between the degree of defects and standard soundness. Soundness is divided into A, B, C and S. A limited use and a countermeasure such as a repair are urgently necessary if the structure is judged as AA in the category of A. The structure grouped in A with general inspection needs an individual inspection. Inspectors judge the degree of soundness of the structure with an individual inspection again. Railway company takes the structure judged A1 with the individual inspection immediately. As for the structure judged A2 in the same way, they repair it in the necessary time. Because the structures judged as A1 or A2 had a defect when they are inspected, such a defect will be likely to be more dangerous in the future.

3. A Inspection Method of Extracting Bridges Caution Needed as to Scouring

RTRI made field investigations of 49 bridges in Aomori, Iwate, Miyagi and Niigata and Nagano Prefectures in Japan. The field investigation results are statistically analyzed. We analyzed the speed (cm/ Year) of local scouring as an objective variable in the quantification method, type I.

The definition of objective variables is as the following.

Partial Scouring Speed:

The riverbed degradation speed around the most scoured pier per year

Table 1 Judgment Classification for Soundness[1)]

Soundness		Adverse Effect	Extent & degree of Defects	Countermeasures
A	**AA**	Immediate Danger	Serious nature	Urgently
	A1	Possible Danger (Near future)	Regressing, or Declining Performance	Immediately
	A2	Possible danger at a later date	Susceptible due to surroundings	As required
B		A, If no action taken	A, If no action taken	Monitoring As required
C		Appropriate at present	Slight	Detailed Inspection at regular interval, if required
S		Sound	Nothing	Unnecessary

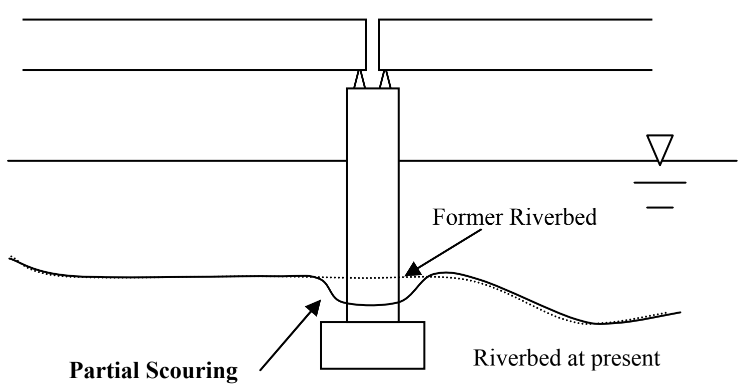

Fig. 1 Partial Scouring

This element was made the objective variable as follows:

1) It has five types of factors, which causes partial scouring under flood conditions due to sand bars, crank flow of channel, channel transition, riverbed configurations and structures.

2) We analyzed previous cases of scouring disasters, partial scouring around the pier causes the damage of the bridge as shown in the figure 1.

We selected eight elements as an explanatory variable. The result is shown in Table 2. We presumed that the graded table can be used with individual inspection. A fundamental point added to the score point of each category which is applicable to every valuation item makes a total point. This total point is the degradation speed (cm/Year) of partial scouring. The key components that regress partial scouring are as follows:

Table 2 the Graded Table for the Estimation of the Scouring Speed

Items	Category			
Average Grain Diameters	***dm***< 2	2<=***dm***< 30	30<=***dm***<100	100<=***dm***
dm(mm)	0.0	9.2	5.5	-6.7
Drainage Area	***S***<=50	50<***S***<=200	200<***S***<=1000	1000<***S***
S(km^2)	-11.7	1.6	5.1	22.5
the Ratio between Radius of Curvature and Channel Breadth	0 < ***r /B*** < ∞	∞ (Straight)		
r /B	1.7	-2.0		
Supercritical Flow or Subcritical Flow	Supercritical	Subcritical		
	16.0	-5.1		
Channel Constriction	No	Yes		
	-2.2	15.8		
Sand bars	No	Yes		
	-3.5	0.9		
Impediment Ratio of River Flow (by Piers)	***P***<=0.1	0.1<***P***<=0.15	0.15<***P***	
P	-2.2	-0.7	4.7	
Frequency of Exceeding the Average of Annual Floods	***N***<=0.66	0.66<***N***		
N (Times / Year)	2.5	-6.9		
Fundamental Point	18.8 (*cm / Year*)			

Prime Elements:

2mm <= Average Grain Diameters < 100mm
Drainage Area > 50 km^2
Channel Constriction: Yes
Impediment Ratio of River Flow > 0.15

4. Application to Inspections

JRs are engaging at the time of the inspection for the safety maintenance of the bridges and piers as follows:

They survey a riverbed around the pier, measure the pier a depth ratio (penetration depth Z / pier width D) , if the pier needs an inspection, and they grasp the regress of scouring at present by recording the measured value.

It is necessary to evaluate the danger of scouring, thus to evaluate the past, present and a future condition from respective viewpoints. As for the past, it is possible to realize the occurrence conditions such as disaster records and the results of the previous inspections. In addition, it is fully understandable with riverbed inspections in view of the present conditions. The satisfactory evaluation will be thereby possible if the rate of pier scour is predicted appropriately in the future.

Thus, we evaluate actual piers as follows:
We evaluate it at the room time calculated from partial scouring speed (cm/year) based on present depth ratio (penetration depth Z / pier width D) that the danger of scouring disaster occurrence was measured as mentioned in the Figure 2. A room time is the period until the ratio is lower than a critical depth ratio. The pier whose room time is short is evaluated as a bridge which it often suffers scouring damage (see Figure 3). Here, the maximum scouring depth can be the maximum depth in the neighborhood of the pier, and it is estimated at Z=1.45D[1]. In addition, a critical depth ratio is the ratio with the root, which copes with this maximum scouring depth.

5. Conclusions

The conclusions of this paper as summarized are in the following:

1) We considered grasping of the bridge environments and the danger due to regress partial scouring based on the data as obtained at present.

2) We evaluate it at the room time calculated from partial scouring speed (cm/year) based on present depth ratio (penetration depth Z / pier width D) that the danger of scouring disaster occurrence was measured.

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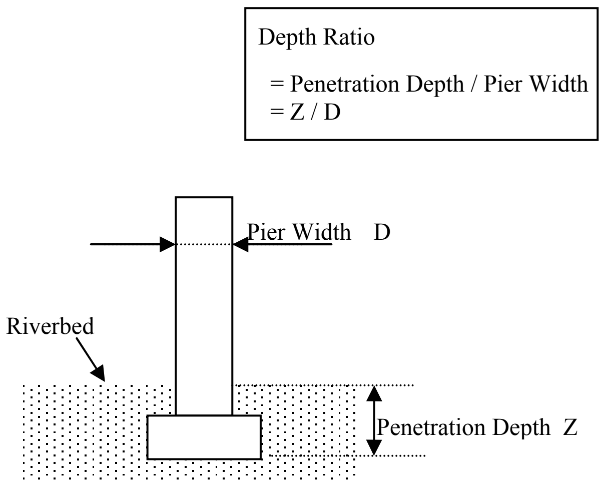

Fig. 2 Depth Ratio

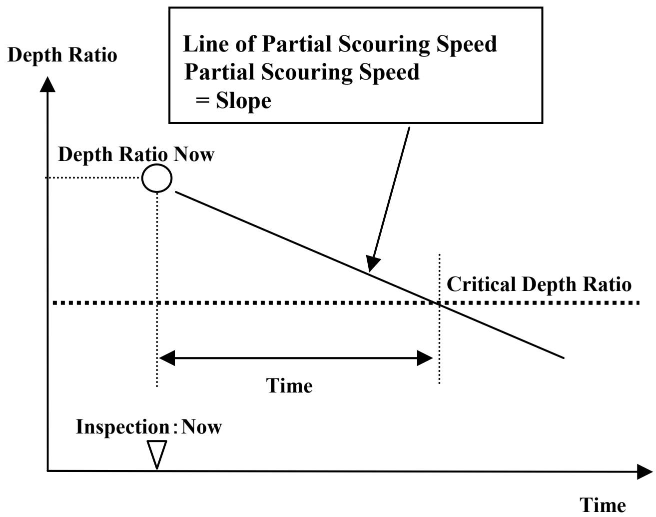

Fig. 3 Evaluation Line