INVESTIGATION OF THE LOCALIZED SCOURING PROCESSES THROUGH AN INTEGRATED APPROACH

RICARDO DE ARAGÃO[1] KOICHI SUZUKI[2] AKIHIRO KADOTA[2]
VAJAPEYAM S. SRINIVASAN[1] and IKEZAWA SHINGO[2]

[1] Department of Civil Engineering, Federal University of Campina Grande, Av. Aprígio Veloso, 882, Bodocongó, Campina Grande, Paraíba, 58109-970, Brazil
(Tel: +55-83-310-1157, Fax: +55-83-310-1388, e-mail: ricardoaragao@yahoo.com)
[2] Department of Civil and Environmental Engineering, Ehime University, Japan
3 Bunkyo-cho, Matsuyama-shi, 790-8577, Ehime-ken, Japan
(Tel: +81-89-927-9831, Fax: +81-89-927-9831, e-mail:ksuzuki@dpc.ehime-u.ac.jp)

In the last century, several bridges failed as a consequence of severe floods that lead to the scouring processes around theirs foundations. Although researches have been conducted on scouring, bridges have failed, proving that the current knowledge is still not enough to asses with confidence the maximum depth of scouring due to a given flood (Dargahi, 1990). To determine the maximum depth, methodologies have been proposed, but they rely on equations developed from data on flume experiments that, in general, neglect important factors of scouring, providing sometimes unrealistic results (Johnson, 1995).

Monitoring of the pier foundations of the Shimanto River Bridge (Japan) has indicated that localized scouring around the piers and downstream from the bridge are increasing considerably. Then to asses a technique for determining the maximum scour depth due to an actual flood and also to evaluate a technique for reducing the scouring downstream from the bridge field survey, flume experiments, and flow simulations were conducted. Those attempts were performed during the period 2001-2003. Each survey consisted of, among other things, an analysis of the probable causes of the localized scouring around the piers that are subjected to the scouring processes only during high flow discharges (P2 to P5), and an analysis of the scouring downstream from piers P6 and P7.

Sediment samples were collected in borings located around P4 and P5, and at sites 20 m upstream (R1) and downstream (R2) from the bridge centerline (Fig. 1a). As a result a sand-gravel bed type of D_{16}= 6 mm, D_{50}=20 mm, and D_{84}=50 mm. To determine the maximum scour depth due to a given flood, a methodology consisting of installing stacks of numbered bricks (21 cm x 6 cm x 9.4 cm) inside the borings previously mentioned was tested (Figs. 1a, 1b). Then, with the removal of both bed material and the bricks on the stacks by floods, by registering the number of the brick left on the top of the stacks and the angle of repose of the streambed sediment (Fig. 1a), the maximum scour depth was determined and the values were compared with those measured during 2002-2003 at the field, being closely related (Table 1).

To analyze the mechanism of the scouring downstream from P6 and P7, underwater visualization, flume experiments, and 3D flow field simulations with model piers were conducted. It was seen that the scour hole has reached almost 10 m in depth and is enlarging streamwise. The simulations showed that the flow going over the blocks between the piers is forced to roll over at the downstream edge of it, generating vortices that impinge on the bed dislodging the sediments and digging a scour hole. These reinforce the observations from flume experiments. To prevent further scouring, flume experiments proved that the use of riprap inside the scour hole could induce the deposition of the transported sediment inside the hole, reducing its maximum depth.

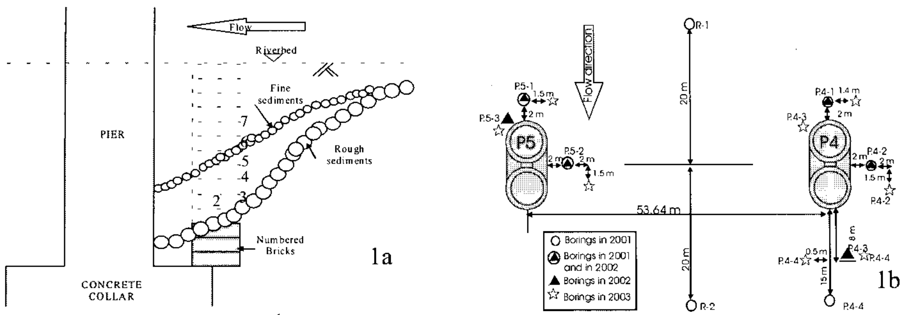

Fig. 1 Removal of bricks from a stack and location of the stacks.

Table 1. Bricks removed from the stacks at P4 and P5 and the related data

Date of observation	2001/07/17 (Installation)	2001/09/14	2002/09/01	2003/05/19	2003/05/31
Peak discharge		2700 m³/s	3100 m³/s	5700 m³/s	6700 m³/s
Flow velocity		1.2 m/s	1.4 m/s	2.6 m/s	3.0 m/s
Max water elevation		4.0 m	4.90 m	6.07 m	6.98 m
P4	Upstream (20 bricks)	0 brick	0 brick	10 bricks	11 bricks
	Left side (20 bricks)	0 brick	1 brick	17 bricks	18 bricks
	Maximum scour depth	3 cm	9 cm	105 cm	111 cm
P5	Upstream (25 bricks)	1 brick	7 bricks	19 bricks	19 bricks
	Left Side (20 bricks)	0 brick	1 brick	20 bricks	20 bricks
	Maximum scour depth	40 cm	76 cm	148 cm	148 cm

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