Çukurova Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, 31(ÖS 2), ss. ÖS 73-ÖS 77, Ekim 2016
Çukurova University Journal of the Faculty of Engineering and Architecture, 31(SI 2), pp. SI 73-SI 77, October 2016

Experimental Investigation of Scour Hole Geometry around Circular Bridge Piers

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Geliş tarihi: 19.07.2016 *Kabul tarihi: 17.09.2016*

Abstract

Failure of the bridges due to local scour around their piers can cause serious life losses and property damages and create significant environmental problems. In this experimental study, scour hole geometry around circular bridge piers were investigated. The experiments were carried out in a rectangular flume 80 cm wide, 18.6 m long and 75 cm high by using uniform sediment with a median diameter of 3.47 mm and geometric standard deviation of 1.39. The experiments were performed under steady state flow conditions, with four different constant discharges.

Keywords: Bridge pier, Clear-water scour

Dairesel Köprü Ayakları Etrafındaki Oyulma Çukuru Geometrisinin Deneysel Araştırılması

Öz

Köprü ayakları etrafındaki yerel oyulmalara bağlı oluşan sorunlar, köprülerin zarar görmesine ve buna bağlı ciddi çevresel etkilere sebep olmakta ve hatta can kayıpları yaşanabilmektedir. Sunulan bu deneysel çalışmada dairsel köprü ayakları etrafında oluşan oyulma çukuru geometrisi incelenmiştir. Deneyler, 80 cm genişlikli, 18,6 m uzunluklu ve 75 cm yükseklikli dikdörtgen kesitli bir kanalda, dane medyan çapı 3,47 mm ve geometrik standart sapması 1,39 olan üniform taban malzemesi ile gerçekleştirilmiştir. Dört farklı debi değeri ile kararlı akım şartlarında deneyler tamamlanmıştır.

Anahtar Kelimeler: Köprü ayağı, Temiz-su oyulması

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1. INTRODUCTION

Local scours around bridge piers influence their stabilities and can cause their failure. Therefore the estimation of the maximum possible scour depth around bridge piers is an important step in the design of the bridge pier foundations. It has been estimated that 60% of all bridge failures result from scour and other hydraulic related causes [1].

Flow parameters, bed material characteristics, pier geometry and time are affected the local scour process. Up to now various experimental researches have been carried out to understand the scour process [2-13].

In this study, the geometries of the scour holes obtained after each experiment were presented. The results can be helpful for future studies to estimate scour hole geometries.

2. EXPERIMENTAL SETUP AND EXPERIMENTAL RESULTS

The experiments were carried out in a rectangular flume 80 cm wide, 18.6 m long and 75 cm deep. Uniform granular sediment with median diameter d_{50} of 3.47 mm and geometric standard deviation of 1.39 was used in the flume. The experiments were performed under steady state flow conditions, with four different constant discharges by using 8 cm. The flow rates and approach flow depths were measured by using electromagnetic flow meter and ultrasonic level sensors, respectively. The slope of the flume was 0.6%. The experimental set-up is given in Figure 1.

Figure 1. Experimental set-up

The bridge piers were located at 11.5 m from the upstream end of the flume as shown in Figure 2.

Figure 2. The location of the bridge pier

The experiments were carried out using four different steady flow rates of 49 l/s, 55 l/s, 59 l/s, 65 l/s. The features of each experiment approach flow depth y, flow rate Q and flow intensity V/V_c is given in Table 1.

The critical velocity V_c was determined from the equation given below [14].

$$\frac{V_c}{u_{*c}} = 5.75 \log\left(5.53 \frac{y}{d_{50}}\right) \quad (1)$$

where u_{*c} is the critical shear velocity which can be calculated using the following relationship [6]:

$$u_{*c} = 0.0115 + 0.0125\, d_{50}^{1.4} \quad for \quad 0.1mm < d_{50} < 1mm \quad (2)$$

$$u_{*c} = 0.0305\, d_{50}^{0.5} - 0.0065\, d_{50}^{-1} \quad for \quad 1mm < d_{50} < 100mm \quad (3)$$

In these relationships u_{*c} is in m/s and sediment size d_{50} is in mm.

Table 1. The details of the experiments

Exp. Ref.	*D (cm)*	*Q (l/s)*	*y (cm)*	V/V_c
1	8	49	21.0	0.37
2	8	55	21.9	0.39
3	8	59	22.8	0.40
4	8	65	23.3	0.43

The scour holes measured after each experiment along the centerline of the flume are shown in Figure 3.

The maximum scour depth d_s and the maximum length of the scour hole L_s measured after each experiment are given in Table 2.

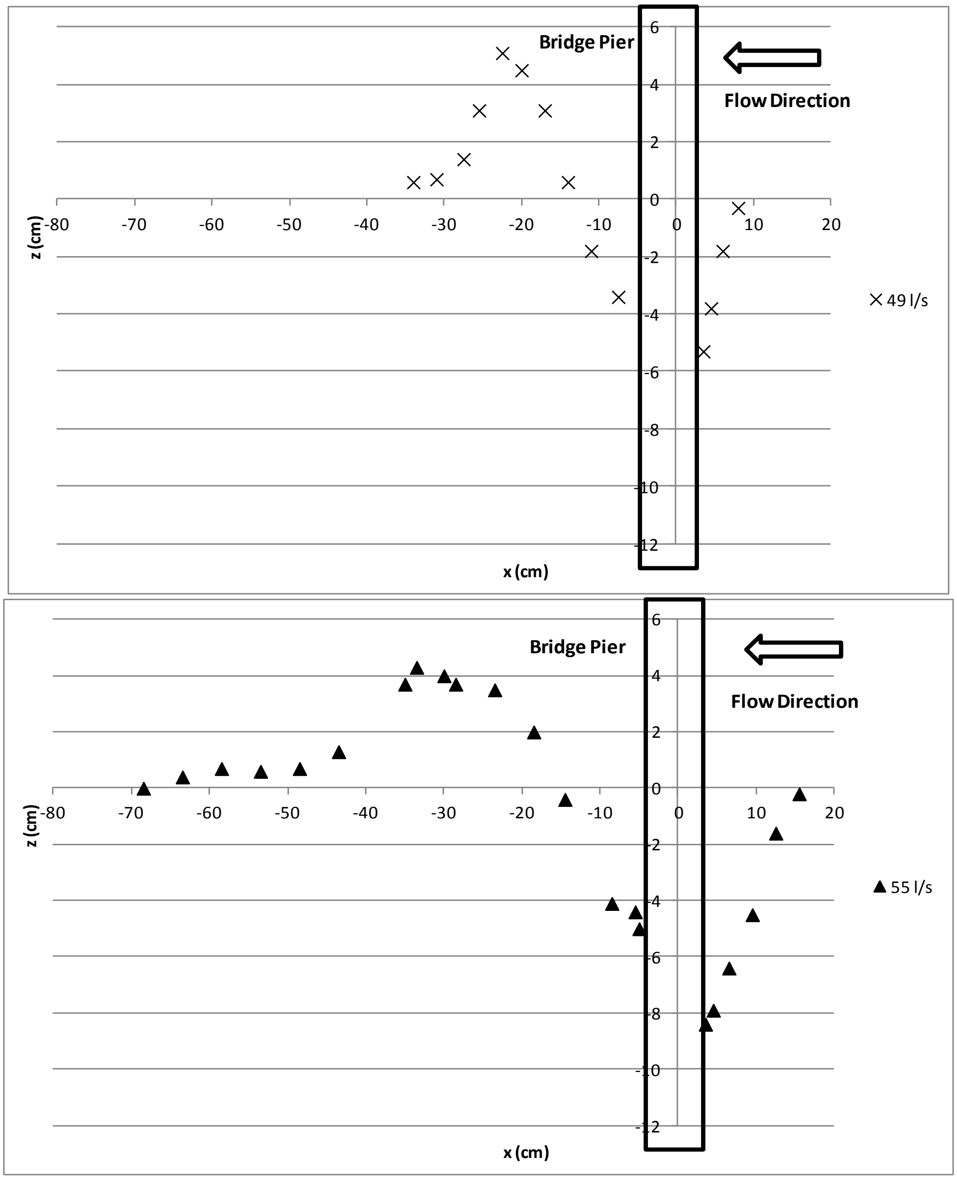
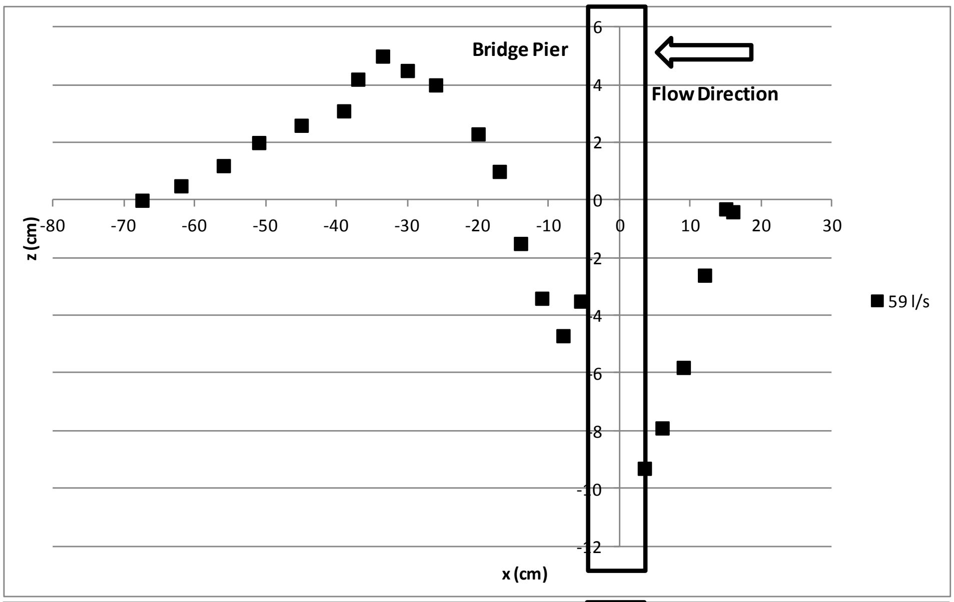


Figure 3. Measured scour hole along the centre line of the flume length for Q=49 l/s, Q=55 l/s, Q=59 l/s, Q= 65 l/s



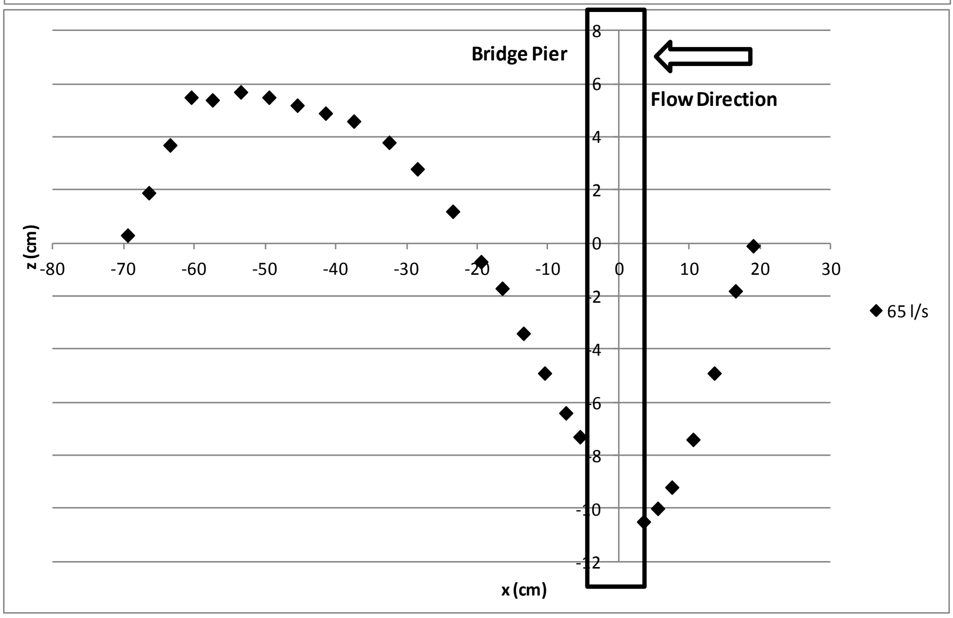


Figure 3. Continue

Table 2. The experimental results

Exp.Ref.	*D (cm)*	*d_s (l/s)*	*L_s (cm)*
1	8	5.3	20.0
2	8	8.4	30.5
3	8	9.3	32.0
4	8	10.5	39.0

The experimental results showed the following:

- Scour depth increased with flow velocity.
- The length of the deposit downstream of the pier and the length of the scour hole increased with flow velocity.

3. CONCLUSION

In this study the local scour around circular bridge piers was investigated experimentally. According to the experimental results, the scour depth increases with increasing flow velocity. It was observed that the length of the deposition downstream of the pier and the length of the scour hole also increase with flow velocity.

4. REFERENCES

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