EXPERIMENTAL STUDY ON GABION STEPPED SPILLWAY

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CONTENT OF THIS PRESENTATION

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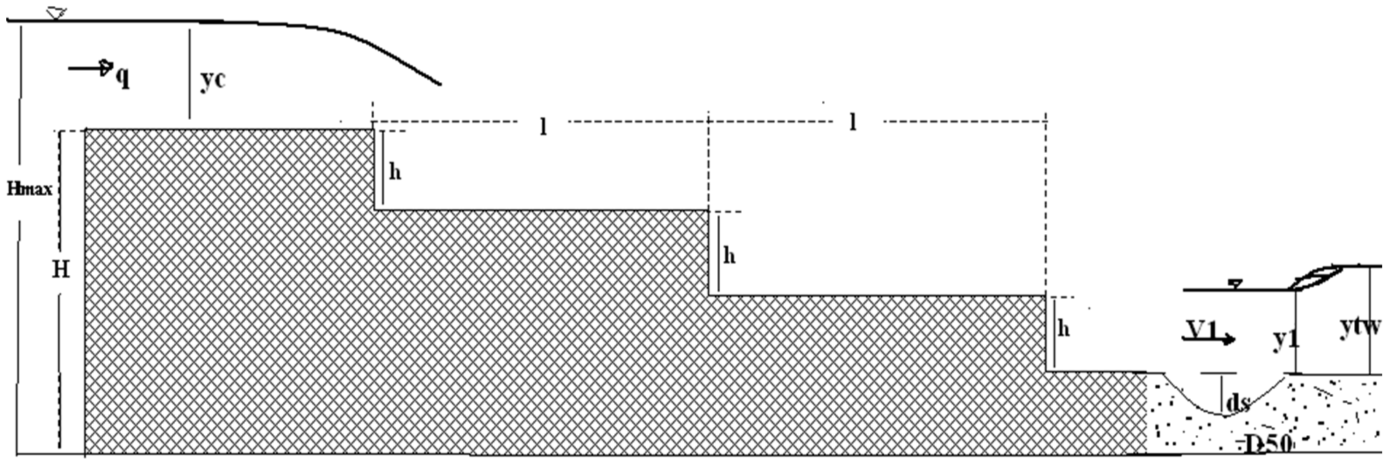
- Purpose of this study
- Experimental set-up
- Results
- Conclusions

Introduction

- Rocks have been used in dam construction, river engineering works, river intakes
- The rock size is important criteria in design which depends on flow characteristics
- When adequate size is not available, gabions are used
- Gabions are hexagonal mesh boxes filled with small sizes of stone. The advantage of gabion are a) their stability b)low cost c) flexibility d)porosity (Chinnarasri, et al. 2003).

Introduction-continued

- The gabion have been used for hydraulic engineering works such as revetments, channel linings, weirs, groins and energy dissipation structures (Stephenson, 1979)
- One application of gabion is for constructing the stepped spillways



Introduction-continued

- Three types of flow occur in gabion stepped spillway: a) “napped flow” when flow cascade from one step to another, b) “skimming flow”, when the water fully flow through the steps and c) “pooled flow” when a step is provided at the end of each step

Introduction-continued

Empirical equations have been developed to distinguish three types of flow.

Table 1 : Formula for distinguish of three types of flow

Type of flow	Formula	Author (s)
Nape flow	$\frac{y_c}{\hbar} = 0.092(\frac{\hbar}{\ell})^{-1.276}$	Chanson (1994)
	$\frac{y_c}{\hbar} = 0.89 - 0.4(\frac{\hbar}{\ell})$	Chanson (2001)
	$\frac{y_c}{\hbar} = 0.80 - (0.55)(\frac{\hbar}{\ell})$	Chinnarasri (2003)
Skimming flow	$\frac{y_c}{\hbar} = 0.862(\hbar / \ell)^{-0.165}$	Yasuda and Ohtsu (1999)
Pooled flow	$\frac{y_c}{\hbar} = [0.55 - 0.16 Ln(\frac{\hbar}{\ell})]^6$	Aigner (2004)

- Energy dissipation in stepped spillway
- Kazemi- Nasaban (1996) and Peyras et al.(1992)

$$\frac{1}{1-\frac{\Delta E}{H}} = a\left(\frac{q^2}{gH^2}\right)^b$$

Table 2 : Values of coefficients of a and b in Eq. (1)

Slope ($h : \ell$)	a	b
1:1	0.238	-0.526
2:1	0.169	-0.654
3:1	0.208	-0.647
3.5:1	1.736	-0.279

- Aigner (2004) developed the following formula:

$$\frac{\Delta E}{H_{\max}} = \frac{\dfrac{H}{y_c}}{\dfrac{H}{y_c} + 1.5}$$

- The cascading and impingement dissipate a lot of the energy, however the scour at the downstream end of the spillway will occur
- The extent of such scour hole may result the instability of the spillway or even its failure.
- Predicting the scour hole depth can help the engineers to design the spillway more safe.
- Review of Literature reveals that no such study, by the knowledge of the authors, has been conducted.
- Therefore: it is the purpose of this study to conduct an experimental tests and to develop a relationship for predicting the maximum scout hole depth, downstream of the gabion stepped spillways.

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Theoretical consideration

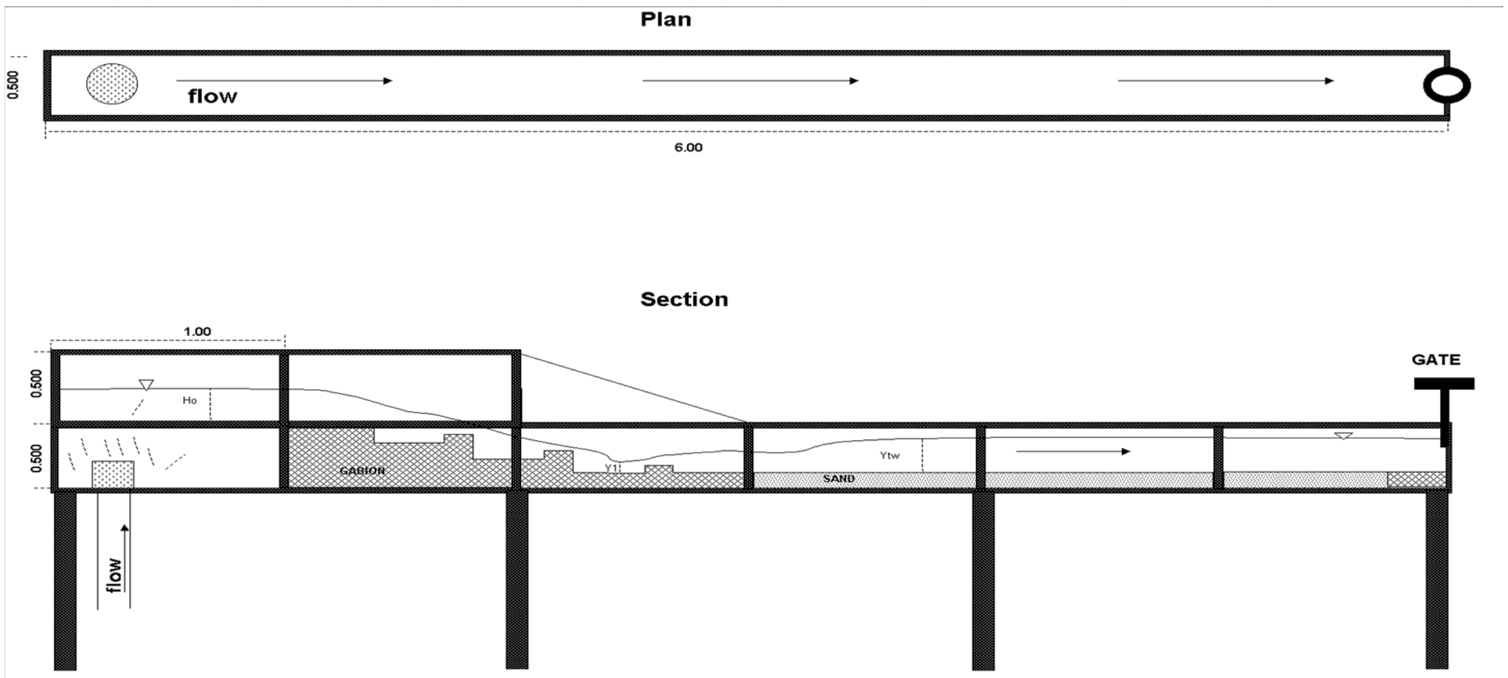
- From the stability analysis of a particle at threshold condition, one can obtain [Shafai-Bajestan etal . (1995)]:

$$\frac{d_s}{D_{50}} = f\left(SN, \frac{y_1}{D_{50}}\right)$$

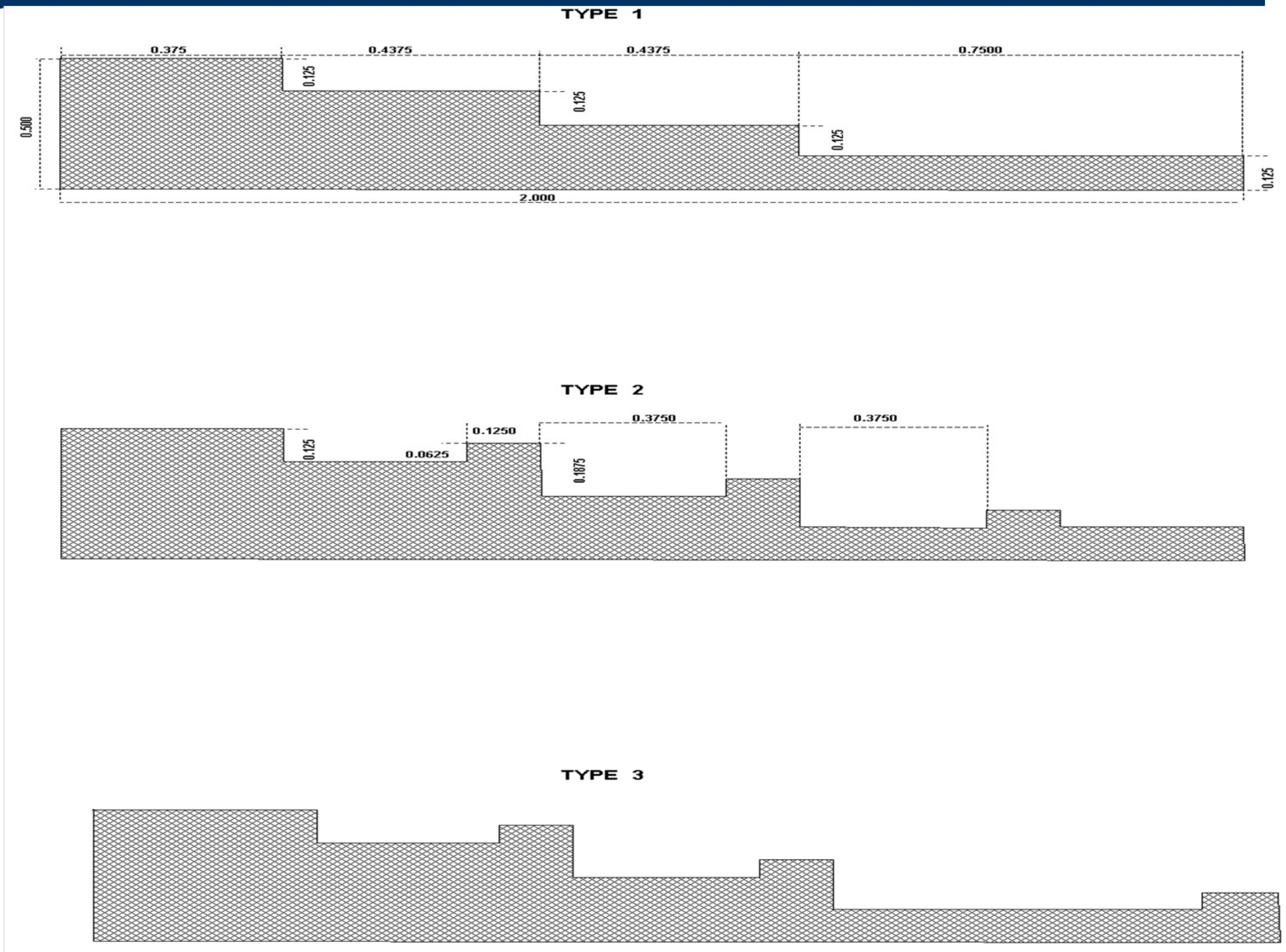
$$SN = \frac{V_1}{\sqrt{g(G_s - 1)D_{50}}}$$

Experimental set_ up

- The experimental tests were conducted in a flume 50 cm wide, 8 meter length and 1.5 m height in the hydraulic laboratory of Shahid_Chamran university



Three types of spillways

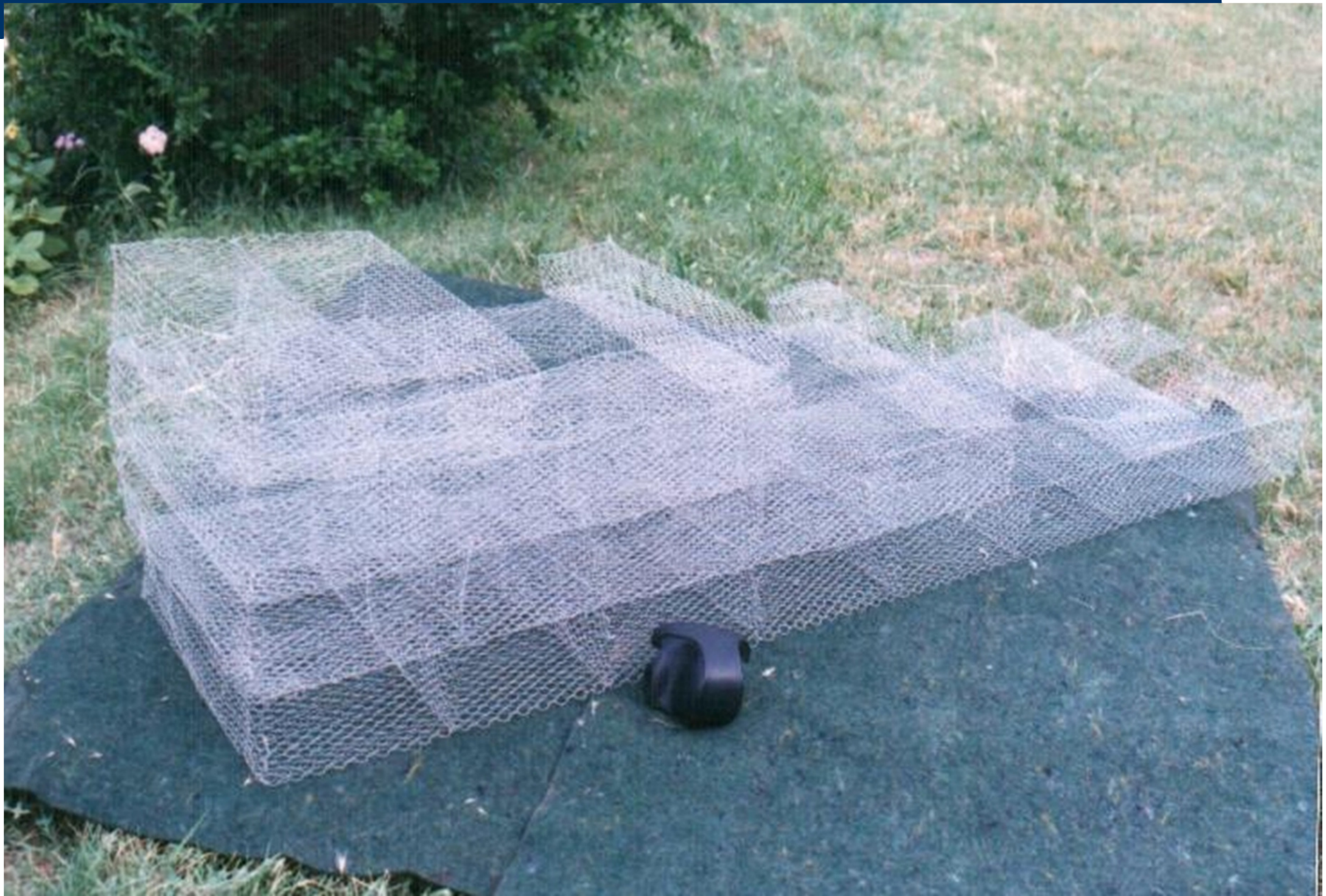


A & B gabion rocks and C, D & E bed materials

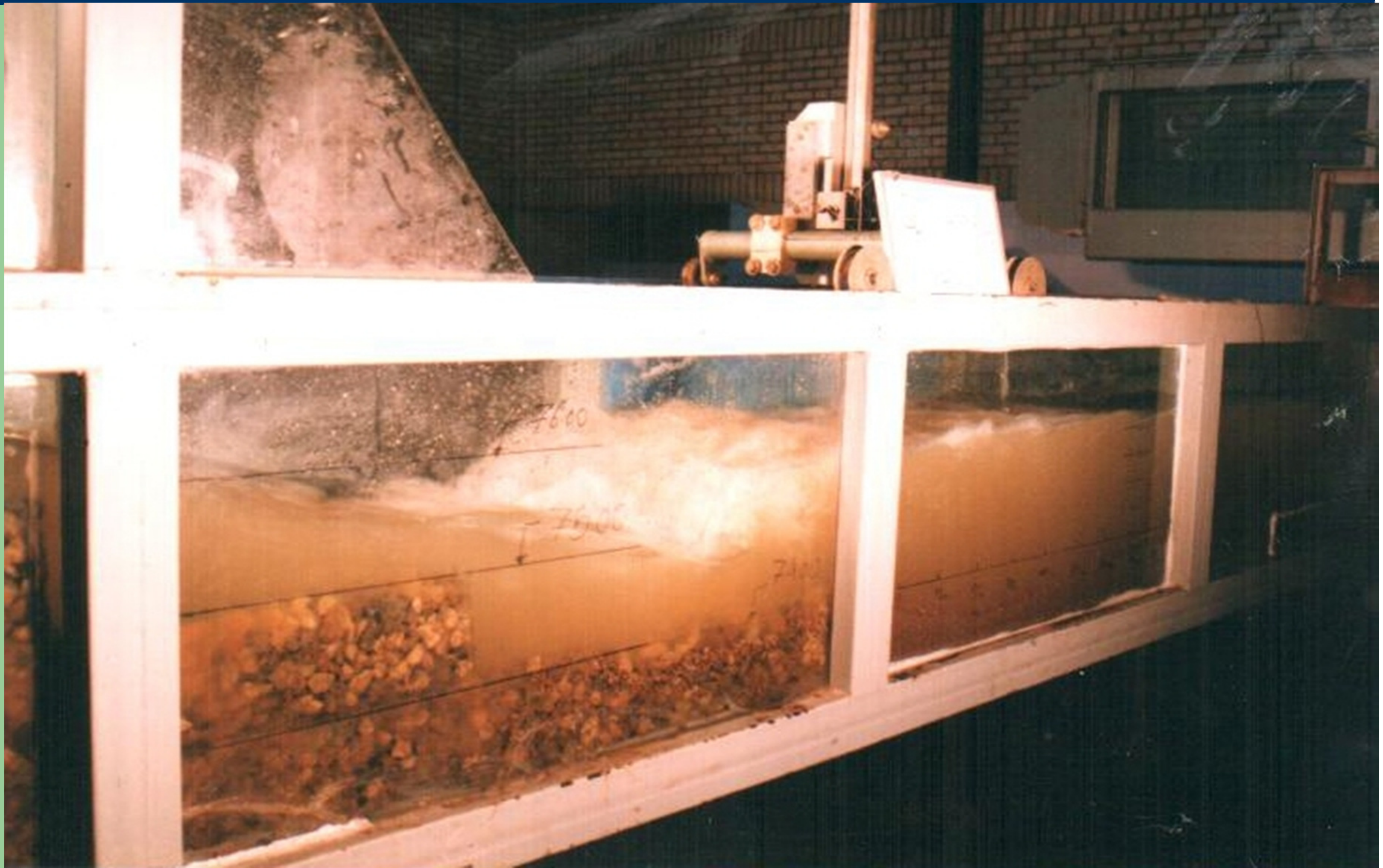
Test procedures

- After placing the desired gabion spillway and bed material, the required flow discharge was established.
- Upon the establishment of the desired flow and tail water depth, the flow characteristics and the scour depth was measured.
- During the test, when little or no removal of bed material from the scour hole is observed, usually 90 minutes from the start of the test, pump was shut down.
- At the end of each test, the scour dimensions were recorded using a bed profiler.

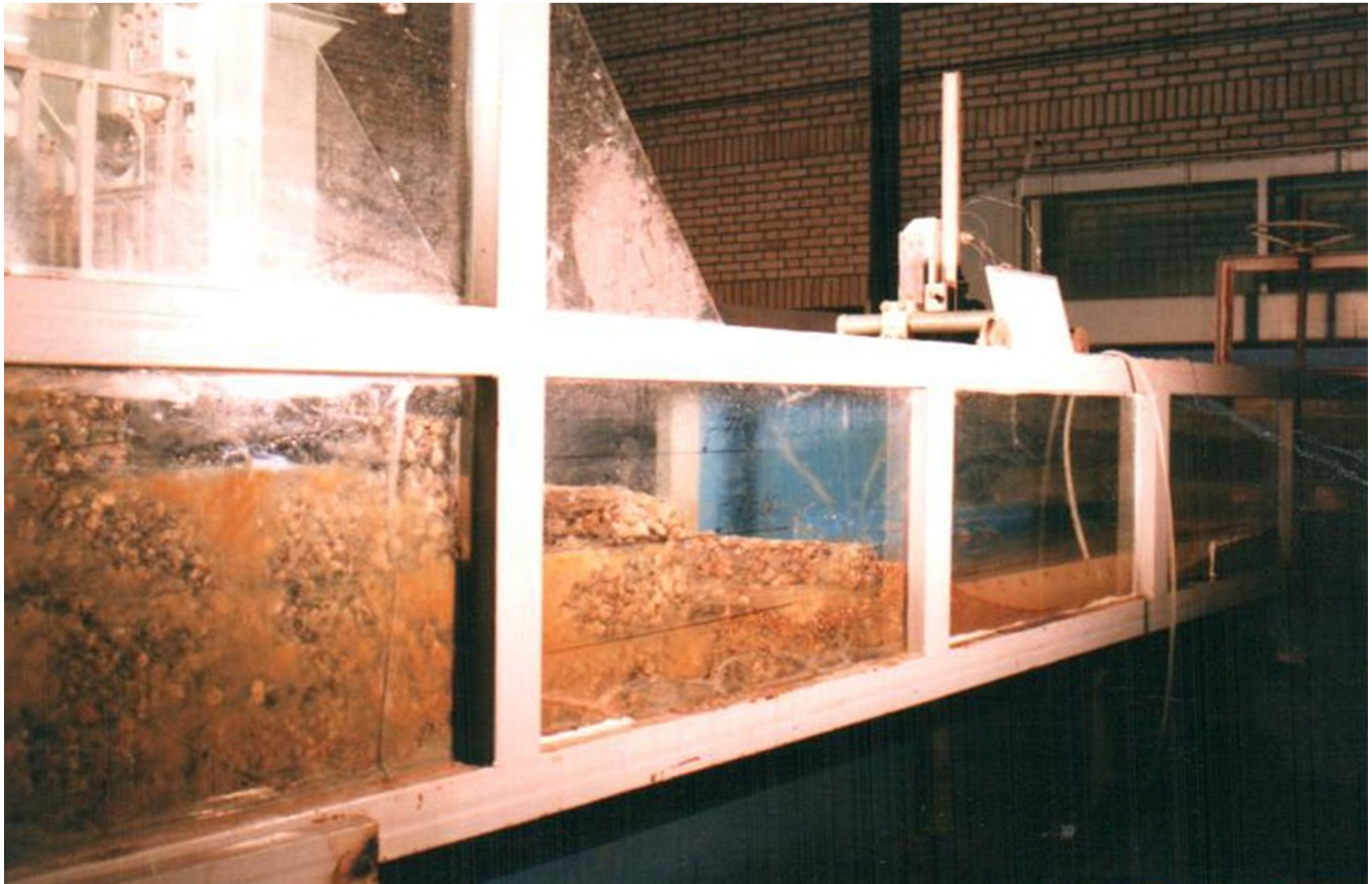
Gabion Nets



Type I spillway



Type II spillway

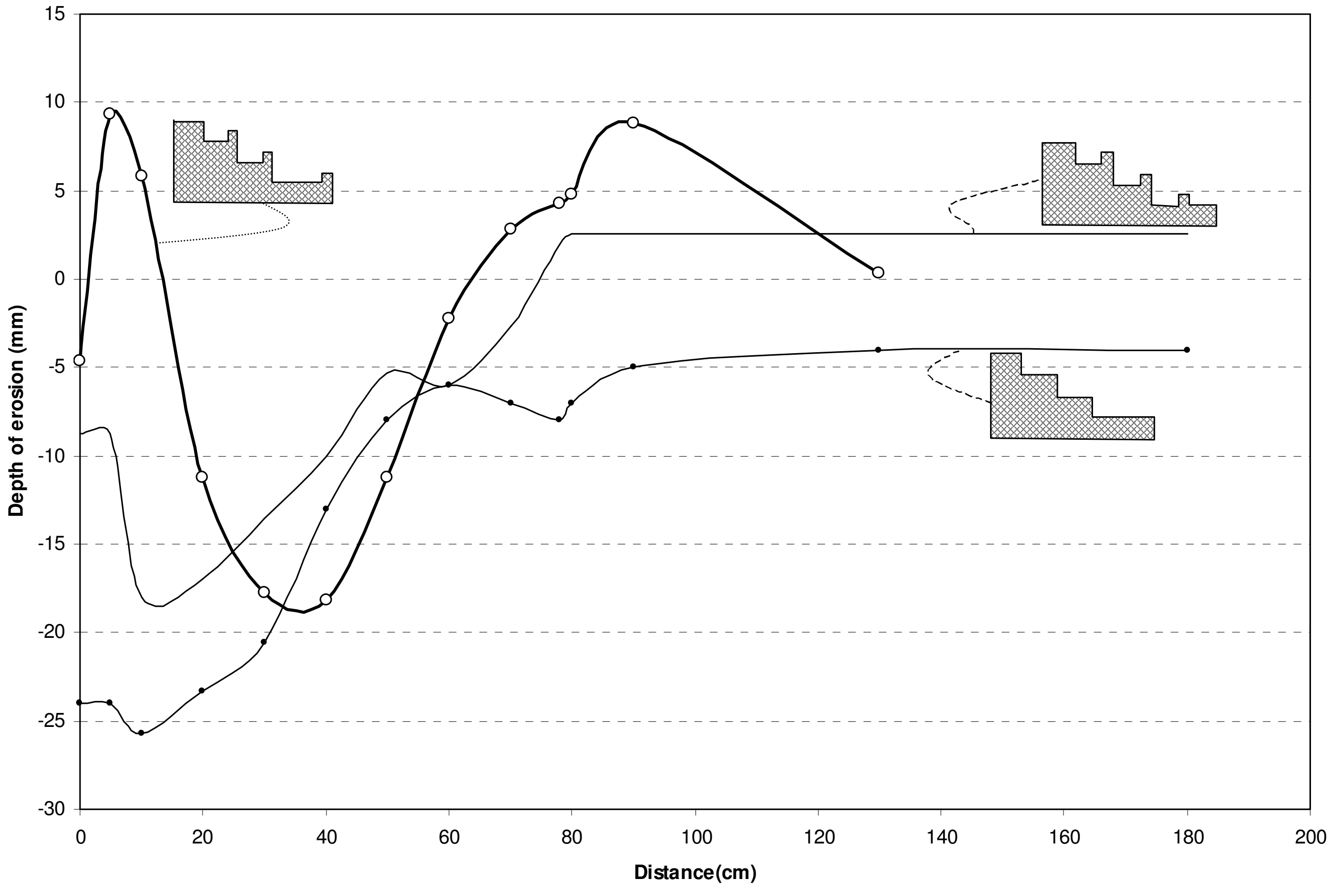


Type III spillway

Scour

Results

Scour profiles at three tests (same flow discharge)



Proposed equations

- For simple gabion stepped spillway (Type I):

$$\frac{ds}{D_{50}} = 0.125\left(\frac{y_1}{D_{50}}\right)^{1.39}(SN)^{0.95}$$

$$r^2 = 0.97$$

For pooled stepped spillway (end sill at the middle of downstream apron):

$$\frac{ds}{D_{50}} = 0.43\left(\frac{y_1}{D_{50}}\right)^{0.98}(SN)^{0.92}$$

$$r^2 = 0.84$$

Proposed equations

- For pooled stepped spillway (end sill at the downstream end of apron) :

$$\frac{ds}{D_{50}} = \left(\frac{y_1}{D_{50}}\right)^{0.54} (SN)^{0.61}$$

$$r^2 = 0.99$$

Conclusions

- In this study three types of gabion stepped spillways under different flow conditions and bed materials were tested.
- Based on stability analysis of a particle at the point of incipient motion, a general formula was developed to predict the scour hole depth.
- By the help of regression analysis technique and use of the experimental data, three equations were developed for prediction of scour depth at downstream of stepped spillways.
- From these equations, one can predict the scour depth.
- It was found that the scour depth downstream of simple gabion stepped spillway is greater than the scour depth for pooled stepped spillway.
- A procedure for design of gabion stepped spillway is presented.

Acknowledgement

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THANK YOU
FOR YOUR
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