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Effect of Mixing Different Grains on Energy Dissipation in Stepped Gabion Spillway

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Abstract: *Stepped gabion can be successfully used for river restoration instead of traditional hydraulic structures. They are elastic structures and preserve the natural environment. They can be easily adapted to the in situ conditions and can be effortlessly modified according to the different hydraulic or geometric conditions which can occur in a natural river. The present study aims to study the effect of mixing different particle diameter samples on flow characteristics. Particles of (5mm, 10mm, 14mm and 15mm) were used to make 6 mixtures with different ratios. The dimensional analysis was used to correlate the different parameters affecting the studied phenomena. It was found that as the finer particles decreased the energy dissipation increased.*

Key Words: *Energy dissipation, Experimental, Theoretical, Gabion, spillway*

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I. Introduction

Rocks in its natural form is the most abundant and economical material in hydraulic engineering practice. Rocks have been used in dam construction, river engineering works, river intakes etc. Gabions are hexagonal mesh boxes filled with small sizes of stone (photo.1, 2). The Gabions retains the advantages of rock fill in its flexibility and permeability so that water pressure is minimized. The wire mesh container can act intension. Nowadays, the gabion is 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. In this structure, the kinetic energy of flow is dissipated, as water flows downstream. Flow through the rock mixes with the flow over the crest, resulting in energy dissipation by Jet impingement as well as due to friction loss through the rock fill. In addition, the energy is dissipated as flow cascade from one step to another. Many researchers interested in this cascade structures **as, (Stephenson, 1979),(Agostini, Bizzarri, Masetti, & Papetti, 1987), (Peyras, Royet, & Degoutte, 1992),(KELLS, 1994), (Shafai-Bejestan & Kazemi-Nasaban, 2011),(Salmasi, Chamani, & Zadeh, 2012), (Vicari, 2014),(G Zhang & Chanson, 2014),(Gangfu Zhang & Chanson, 2016),(Vashisth, 2017)**

photo.1"some gabions models"

photo.2 "Gabion stepped spillway used to reduce water velocity and to collect sediments in mountain valley (left), and gabion structure in a retaining wall for slope stability (right) on Onebne-Ali mountain, north of Tabriz (IRAN) "

In this study the effect of changing mixing different ratios of different particle size was studied and the resultant data were compared. The results were used to show the effect on different flow characteristics.

II. Experimental setup

Experimental work was carried out in the Hydraulic and water Engineering Laboratory of the Faculty of Engineering, Zagazig University, Egypt. The used flume is 30 cm width, 46.8 cm depth with an overall length of about 15.6 m. The flume is equipped with a tailgate to control the tail water depth. A pump lifts the water from a tank to the flume inlet. The water runs through the flume working section then returns back to the tank in a closed circle. The discharge was measured by a pre-calibrated orifice meter installed in the feeding pipe line.
The used stepped spillway model is made from metal covered with metal narrow mesh with 28 cm height and 7 steppes 7cm horizontal and 4 cm vertical each as shown in photo 5. Different particle size (5mm, 10mm, 14mm and 20mm) were mixed in different ratios (25%, 50% and 75%) mutually and tested under the same flow conditions.

Photo (3) Gabion experimental model

III. Dimensional analysis

Using the principals of the dimensional analysis, the different variables affecting the energy dissipation through the spillway could be formulated in the following dimensionless equation:

$$\frac{\Delta E}{E_{up}} = f(F_{up}, \frac{D_1}{D_2})$$

$$\frac{L_J}{Y_{up}} = f(F_{up}, \frac{D_1}{D_2})$$

$$\frac{Y_2}{Y_{up}} = f(F_{up}, \frac{D_1}{D_2})$$

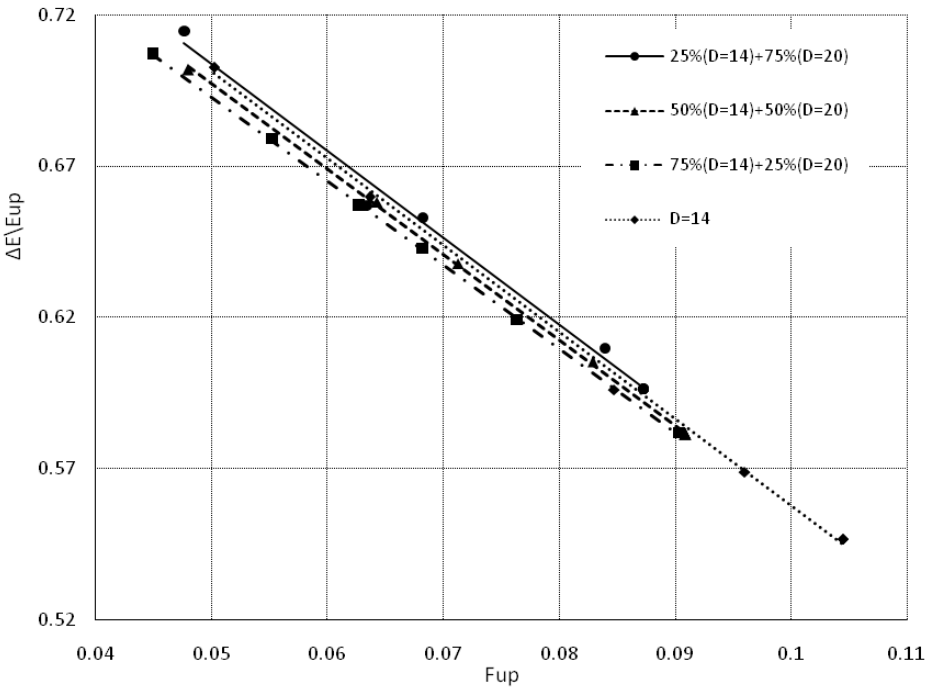
Where

ΔE is the total energy loss, E_{up} is the upstreamenergy, D is the particle size, h_s is the spillway upstream depth, Y_{up} is the upstream water depth,Y_2 is the upstream water depth, B_s is the spillway width and F_{up} is the upstream Froude number, L_j is the jump length

IV. Analysis of Experimental Results

4.1 Mixing of diameters 14mm and 20mm

Fig.1 represents the relationship between the upstream Froude number F_{up} and the relative energy loss $\Delta E/E_{up}$ for different contraction ratios. From this figure, for the same mixing ratios, as Froude number increases the relative energy loss decreases.. Moreover, for the same Froude number, the relative energy loss increases as the ratio of finer particle decreases. The relative tail water depth and the relative hydraulic jump length were plotted against the U.S. Froude no. as shown in Fig. 2, 3. From those figures for the same mixing ratios the relative tail water depth and the relative hydraulic jump length increases as Froude number increases. Also, the relative tail water depth and relative hydraulic jump decrease as the ratio of finer particle increases



Figure(1) Relations between F_{UP} and $\Delta E/E_{up}$` for14, 20 mm diameters different mixtures.

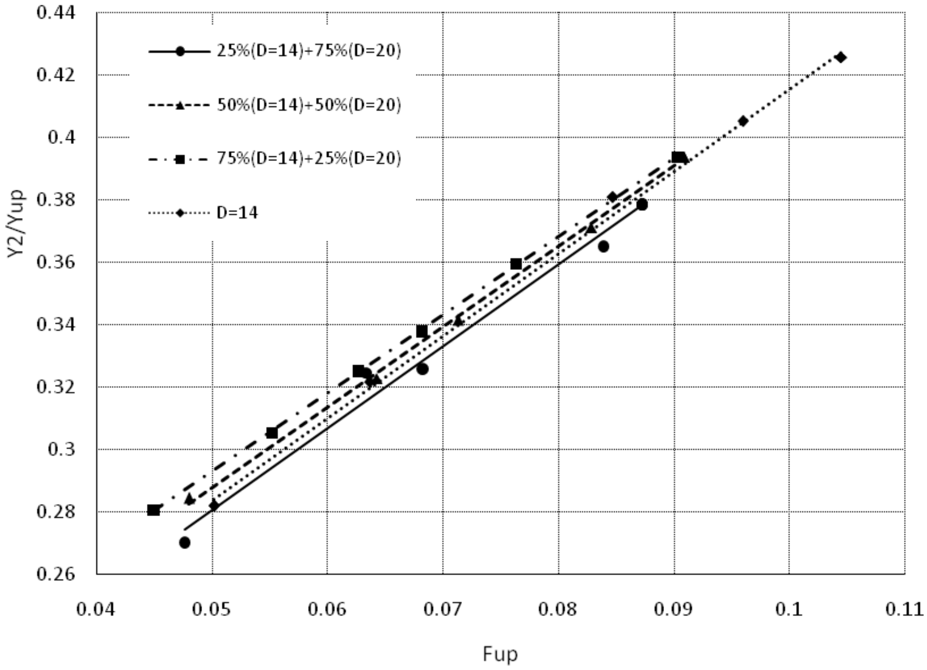


Figure (2) Relation between F_{UP} and Y_2/Y_{UP} for 14, 20 mm diameters different mixtures.

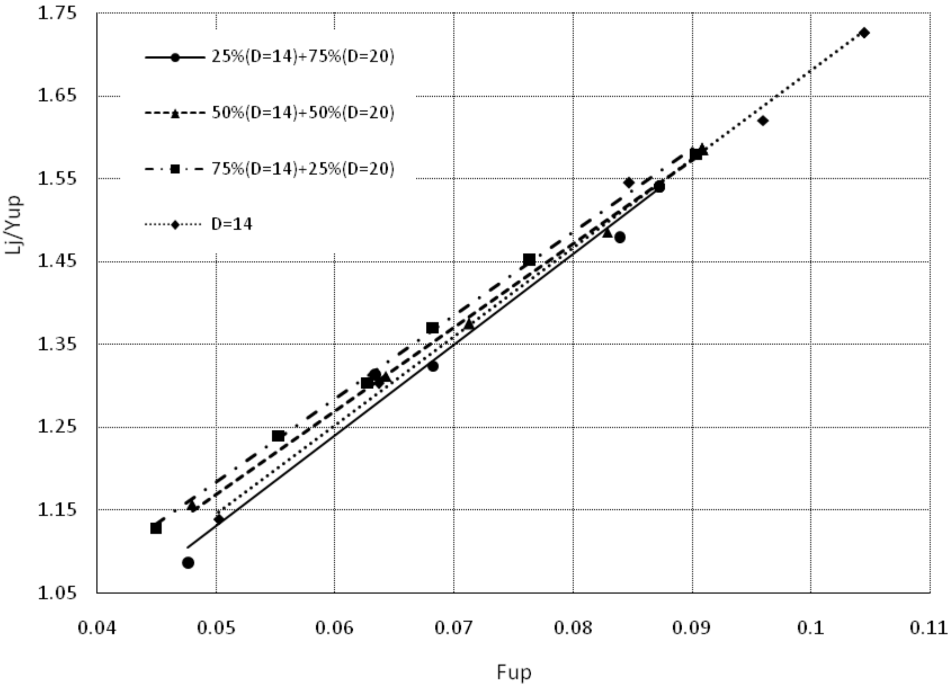


Figure (3) Relation between F_{UP} and L_j/Y_2 for 14, 20 mm diameters different mixtures.

4.2 Mixing of diameters 5mm and 10mm

Fig.4 represents the relationship between the upstream Froude number $F_{up}$and the relative energy loss $\Delta E/E_{up}$ for different contraction ratios. From this figure, for the same mixing ratios, as Froude number increases the relative energy loss decreases.. Moreover, for the same Froude number, the relative energy loss increases as the ratio of finer particle decreases. The relative tail water depth and the relative hydraulic jump length were plotted against the U.S. Froude no. as shown in Fig. 5, 6. From those figures for the same mixing ratios the relative tail water depth and the relative hydraulic jump length increases as Froude number increases. Also, the relative tail water depth and relative hydraulic jump decrease as the ratio of finer particle increases

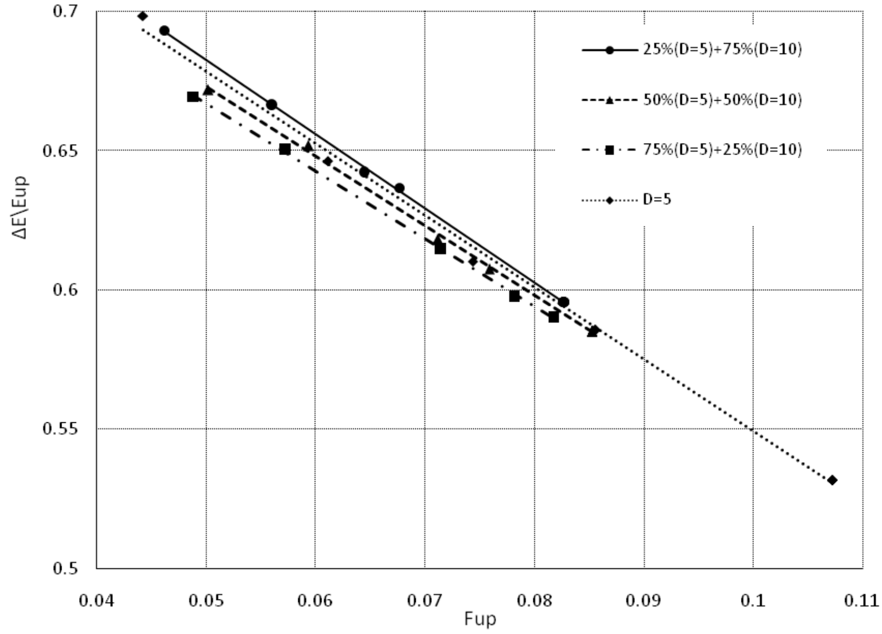


Figure (4) Relations between F_{UP} and $\Delta E / E_{up}$ `for 5, 10 mm diameters different mixtures.

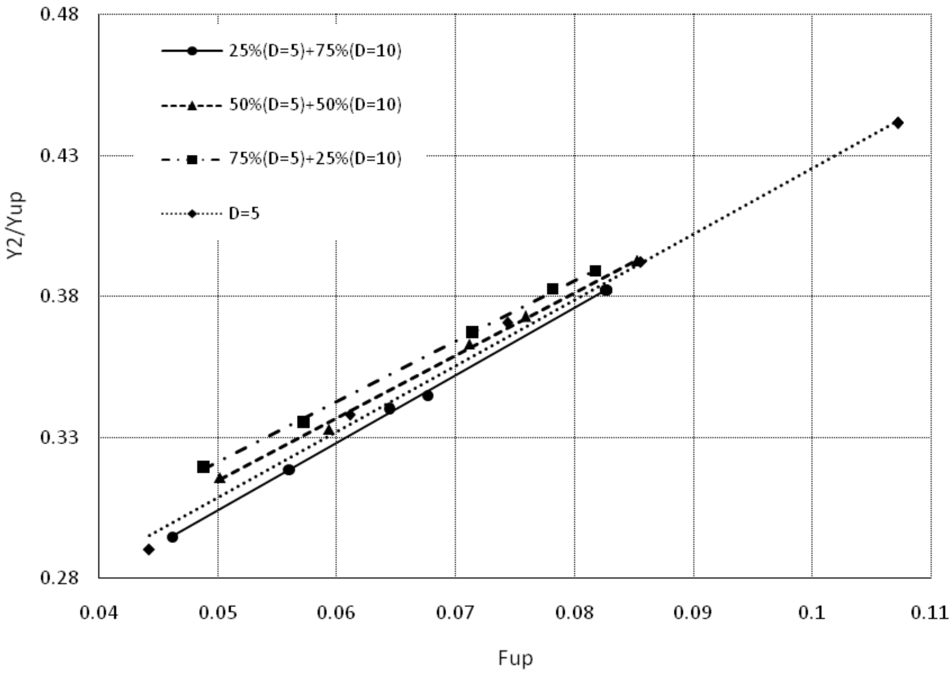


Figure (5) Relation between F_{UP} and Y_2 / Y_{UP} for 5, 10 mm diameters different mixtures.

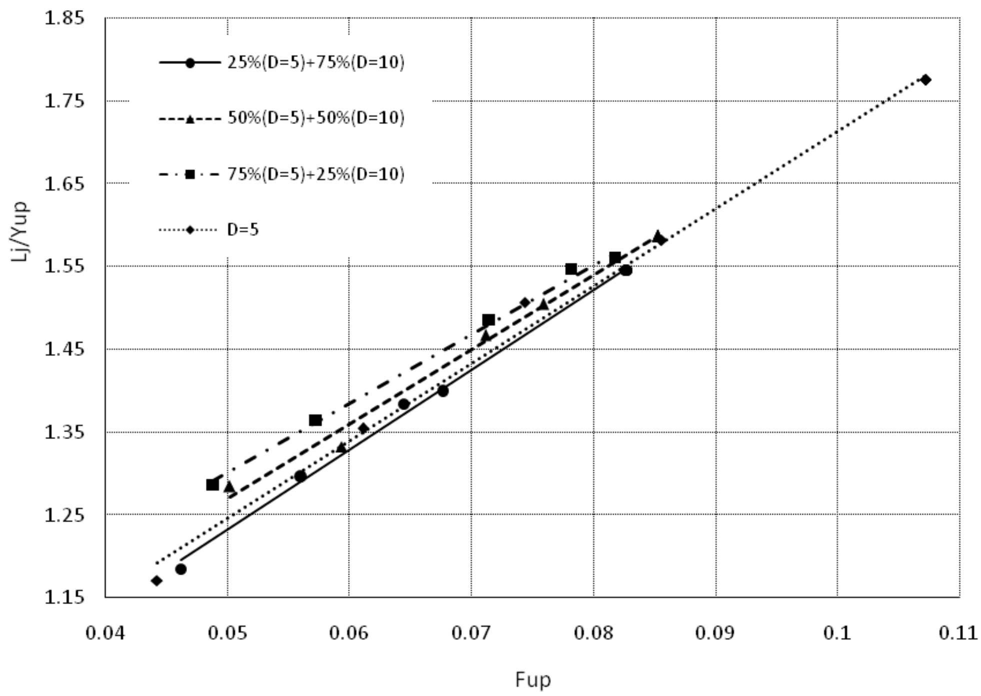


Figure (6) Relation between F_{UP} and L_j/Y_2 for 5, 10 mm diameters different mixtures.

Conclusions

The present study introduced the following results.

1- The large particle size increased energy dissipation for the same Froude number.
2- As the coarse particle ratio increased the energy dissipation increased.
3- As energy dissipation increased the relative tail water depth and relative jump length decreased.

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