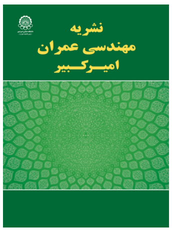

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The Study of Energy Dissipation Due to the Use of Vertical Screen in the Downstream of Inclined Drops by Adaptive Neuro-Fuzzy Inference System (ANFIS)

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ABSTRACT: The aim of the current study, investigate the energy dissipation of the use of the vertical screen with two porosity ratios downstream of the inclined drop with three different angles, two heights of the drop, and the range of 200-700 l/min with an analysis of 140 laboratory models. The results revealed that the use of screens caused by an increase of at least 407% and a maximum of 903% of total relative energy dissipation efficiency to the plain inclined drop. The equations were presented to estimate the relative energy dissipation due to the use of a vertical screen downstream of the inclined drop with acceptable assessment criteria. Also, the contribution of each of the energy dissipation systems was presented. Then, intelligent models, Artificial neural network (ANN), and adaptive neuro-fuzzy inference system (ANFIS) were compared to estimate the relative energy dissipation using three parameters θ, P, and yc/Δz using evaluation criteria. The values of R2 and RMSE for the ANFIS model, were 0.996 and 0.006, respectively, and for the ANN model were 0.992 and 0.008 respectively, which revealed the higher accuracy of the ANFIS model in the estimation of the relative energy dissipation than the ANN.

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Screen, Sub-critical flow.

1. Introduction

The kinetic energy of the flow increases the downstream of the drops. Extension structures are used to reduce this energy. Screens reduce the kinetic energy of the flow by causing weather interference, imposing a hydraulic jump, and stabilizing at the downstream of the supercritical flow-generating structures. Daneshfaraz et al. [1] investigated the effect of the screen's location on the flow's energy dissipation. The results revealed that the presence of the screens caused by increased energy dissipation compared to the free jump. Daneshfaraz et al. [2] investigated the effect of baffle performance with vertical screens downstream of the gate. The results revealed that models with baffle had more energy dissipation than without baffle models. The present study was performed for the first time to investigate the energy dissipation downstream of inclined drops by using screens. In addition, two intelligent models of artificial neural network (ANN) and the adaptive neuro-fuzzy inference system (ANFIS) were used to estimate relative energy dissipation and their results were compared.

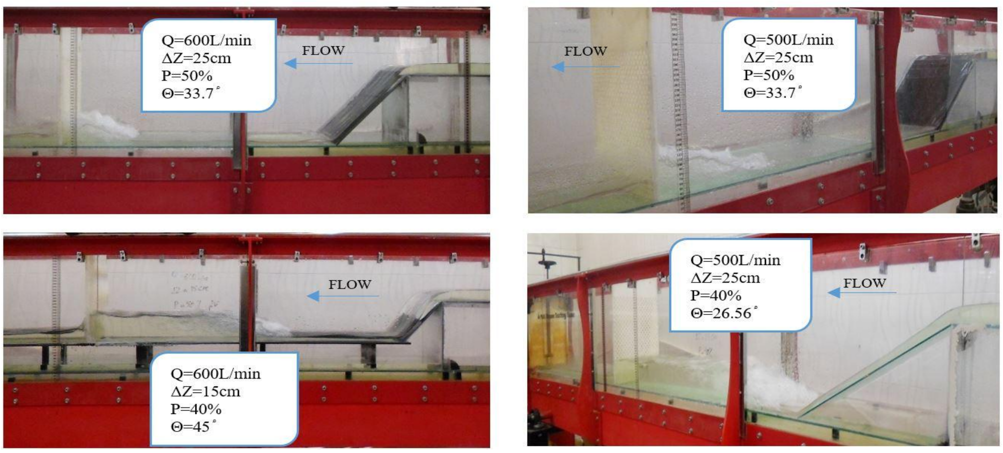

Fig. 1. View of inclined drop equipped with vertical screens.

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2. Methodology

To evaluate the effect parameters, the physical model was used in the hydraulic laboratory of Maragheh University. Experiments were conducted in a horizontal flume with a length of 5m, a width of 0.45m, and a height of 0.3m. The inclined drops were composed of glass boxes with two heights of 0.15, and 0.25m, and three angles of 26.56°, 33.7°, and 45°. Screens are made of polyethylene, with circular orifices and porosity ratios of 40, and 50%. Fig. 1 indicates an overview of the inclined drop equipped with a screen in the laboratory.

Dimensional analysis was performed by using the π-Buckingham theory and considering as duplicating variables and the dependent hydraulic quantity of relative energy dissipation was extracted based on dimensions independent parameters according to Eq. (1).

$$\frac{\Delta E}{E_0} = f_4(\theta, p, \frac{y_c}{\Delta z}) \qquad (1)$$

Where p is the porosity of the screen, θ is the angle of drop and yc/Δz is the relative critical depth.

3. Results and Discussion

The relative energy dissipation changes based on the dimensional analysis, for plain inclined drops and inclined drops equipped with the vertical screen, with three angles and two ratios of porosity 40 and 50%, depends on the relative critical depth. Relative energy dissipation calculation resulted from the present study was compared with the results of the study of Moradi Sabz Koohi et al. [3] for plain inclined drops in two angles of 56.26 and 7.33 degrees to the relative critical depth. In all data of the present study and Moradi Sabz Koohi et al. [3], the relative energy dissipation decreased by increasing relative critical depth. The results indicate that the plain inclined drop of the present study was conducted at two angles of 26.56 and 33.7 degrees with the results of the study of Moradi Sabz Koohi et al. [3] is in close agreement.

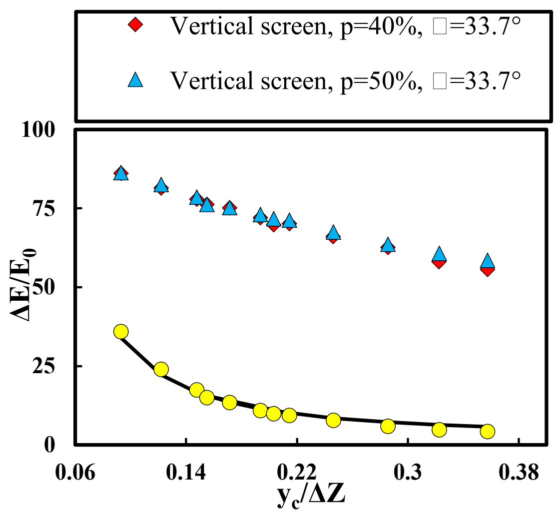

Fig. 2. Relative critical depth changes versus the relative energy dissipation.

Table 1. The results of ANN, ANFIS, and Eq. (13) models for training and test periods.

	Testing Data		Training Data	
	R2	*RMSE*	*R2*	*RMSE*
ANN	0.9925	0.008	0.989	0.0084
ANFIS	0.9966	0.006	0.991	0.0069
Equ.13	0.9036	0.195	0.893	0.203

Also, at a constant discharge (constant relative critical depth) energy dissipation increases by increasing drop height and increasing slope. In the present study can also be found that the presence of screens significantly increased the energy dissipation at all three slope angles by comparing the inclined drop equipped with vertical screens and plain inclined drop. A nonlinear Eq. (2) considering the experimental data for calculating the energy dissipation at the downstream of inclined drop equipped with vertical screens are presented.

$$\frac{\Delta E}{E_0} = -1.052(\frac{y_c}{\Delta Z})^{0.429} \times 0.352(\theta)^{0.205} \times 0.943(p)^{-0.005} + 1.201 \qquad (2)$$

Statistical criteria indicate that the ANFIS is more accurate than the ANN and the equation obtained from the experimental data. As seen, the ANFIS has provided very similar results to the laboratory values in predicting the amount of relative energy dissipation downstream of inclined drops with the use of screens (Table 1).

4. Conclusions

In the present study, the energy dissipation was investigated downstream of the inclined drops by using screens. The results indicated that at a constant flow rate, the energy dissipation increases by increasing drop height and slope angle. In the present study can also be found that the presence of screens significantly increased the energy dissipation at all three slope angles by comparing the inclined drop equipped with vertical screens and plain inclined drop. The screens used in inclined drops increased the total energy dissipation compared to the plain inclined drop of the 40% porosity for the Angles 26.56, 33.7, and 45 degrees respectively 9.89, 7.19, and 5.07. It also increases the porosity ratio of 50% for the given angles by 10.03, 7.36, and 5.23 times, respectively. By increasing the height of the inclined drop equipped with vertical screens 50% porosity compared to the 40% porosity, the contribution of the energy dissipation of the inclined drop and hydraulic jump increases, and the proportion of the screens decreases. Also, the two intelligent models of ANN and the ANFIS model were used in estimating relative energy dissipation (ΔE/E0) using 3 parameters θ, P, and yc/z. Then the estimated values (ΔE/E0) were compared with the mentioned models using evaluation criteria. The results of this study revealed that both intelligent models have better accuracy in estimating (ΔE/E0). ANFIS compared to ANN with R2 and RMSE 0.996 and 0.006 for ANFIS and 0.992 and 0.008 for ANN, respectively. It is highly accurate.

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