



Experimental investigating on hydraulic parameters of vertical drop equipped with combined screens

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ABSTRACT: In many overflow structures such as vertical drops, using the flow energy dissipator and investigating the subsequent effect on the hydraulic parameters are the most important issues in hydraulics. This study experimentally investigates the behavior of hydraulic parameters through the utilization of combined screens (horizontal-vertical) in vertical drops. The results revealed that the utilization of the screens combined with vertical drops reduces the relative mixing length and increases the relative pool depth and relative energy loss with respect to a plain vertical drop. It was also observed that the increase in the relative critical depth result in the increase in the relative wetted length of the vertical screens, the relative mixing length and the relative pool depth, and decrease in the relative energy loss. Evaluating the total energy dissipation of system by the effective components of energy dissipation exhibited that, by increasing relative critical depth, the performance of vertical drop equipped with horizontal screen decreases and the performance of vertical screen increases. However, the contribution of vertical drop equipped with a horizontal screen is more than 82% of the total energy loss of the system. Also, increasing the porosity of screen reduces the relative wetted length of horizontal and vertical screens, the relative mixing length and relative pool depth, and increase the relative energy loss.

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1. INTRODUCTION

Vertical drops are commonly-used structures which are utilized in the open channels in order to dissipate the energy of water flow [1, 2]. In spite of vertical drops, energy dissipation can be increased by screen-type structures, which are located downstream of drops. The hydraulic behavior of vertical drop equipped with screen-type dissipators was evaluated by Kabiri Samani et al. [3]. They revealed that screen-type dissipators increase relative energy loss than plain vertical drops. Daneshfaraz et al. [4] evaluated the energy dissipation at the brink of vertical drops with a parallel supercritical flow at upstream of drops. They found that the vertical drops equipped with horizontal screens have lower relative downstream depth, relative pool depth, and higher energy dissipation than plain drops. An overall review of previous studies exhibits that there is no study related to the

evaluation of the combined vertical and horizontal screens at downstream of drops. In this study, the effect of combined usage of the vertical and horizontal screen on the hydraulic behavior of drops are evaluated.

2. MATERIALS AND METHODS

Experiments were conducted in a horizontal flume at the University of Maragheh with a length of 5m, a width of 0.45m and a height of 0.3m. The drops were composed of glass boxes and screens were made from polyethylene sheets with holes. Fig. 1 illustrates the general schematics of the model, and Table 1 represents the characteristics of the model.

In order to evaluate the behavior of vertical drop equipped with combined screens as the goal of the study, firstly, effective parameters are identified and then, the dimensionless parameters were derived through the π -Buckingham theory

Table 1. Geometric characteristics of the vertical drop equipped with a combined screen

screens						Vertical drop		
Vertical			Horizontal			Height (cm)	Width (cm)	Length (cm)
Porosity (-)	Width (cm)	Length (cm)	Porosity (-)	Width (cm)	Length (cm)			
40% - 50%	30	30	40% - 50%	30	70	20	30	120

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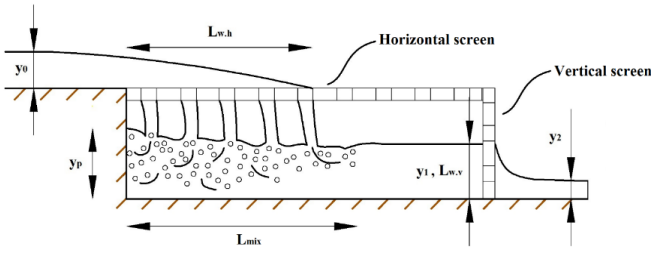


Fig. 1. Schematic view of the flow in the vertical drop equipped with a combined screen

as follows.

$$\frac{\Delta E}{E_0}, \frac{L_{mix}}{h}, \frac{L_{w.v}}{h}, \frac{y_p}{h} = f_1\left(\frac{y_c}{h}, p\right) \quad (1)$$

$$\frac{L_{w.h}}{y_c} = f_2(Fr_0, p) \quad (2)$$

3. RESULTS AND DISCUSSION

3.1 Relative length of the wet

The relative wetted length of horizontal and vertical screens is one of the important parameters, which are used in the optimal and economical design of drops. The result revealed that an increase in upstream Froude number, increases the relative wetted length of the horizontal screens, and increase in relative critical depth leads to increase in the relative wetted length of the vertical screens. However, for a same condition, by increasing a porosity percentage, the relative wetted length of horizontal and vertical screens decreases.

3.2. Relative mixing length

The distance between the brink of a drop to the end of turbulence induced by hydraulic jump and collision of flow jet with pool named as mixing length. Fig. 2 depicts the variation of the relative length of mixing in the basin located at downstream of vertical drops equipped by screens with different porosities versus relative critical depth.

Results reveal that using combined screens in vertical drops result in decreasing the relative length of the stilling basin than plain drops. The comparison between the results of screen porosity shows that screens with 50% porosity have a lower length of mixing than screens with 40% porosity.

3.3. Relative energy loss

Fig. 3 shows the variation of relative energy loss of vertical drop equipped by combined screens and plain vertical drop in the subcritical flow regime at upstream of the drop. This figure indicates that using the combined screens in vertical drops with subcritical flow leads to a higher energy loss than plain drops. Energy dissipation occurs due to the fragmentation of flow jet by horizontal screen, turbulence induced by the collision of fragmented jets with pool, and turbulence induced by flow passing through vertical drops.

The comparison of results related to the effect of screen porosity on energy dissipation indicates that screen porosity

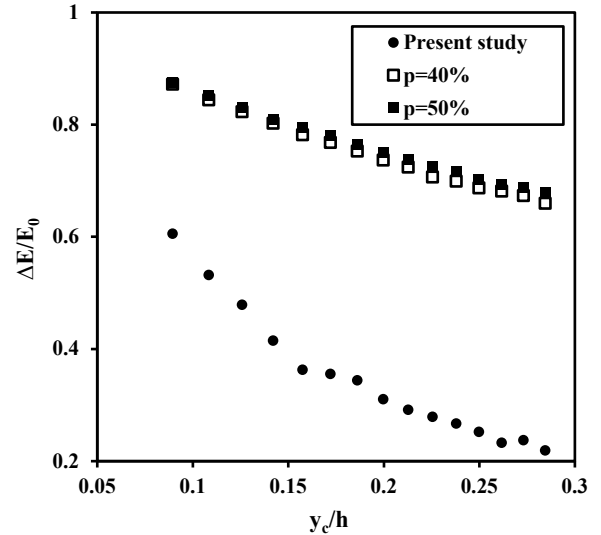


Fig. 3. Variation relative energy loss versus relative critical depth

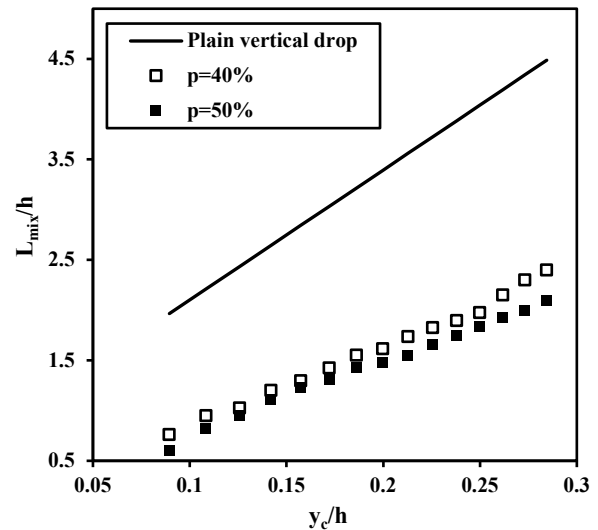


Fig. 2. Variation of the relative mixing length of the flow versus relative critical depth

has insignificant influence on energy dissipation. Also, the evaluation of energy dissipation induced by different components shows that the vertical drop and horizontal screen have a significant contribution to energy dissipation. However, a small portion of the total energy is dissipated by the component of the vertical screen. The vertical drop and horizontal screen dissipate more than 82% of the total energy of the system.

4. CONCLUSIONS

In the present study, the effect of using combined screens (horizontal and vertical) in vertical drops were evaluated on the hydraulic parameters of these structures. Results showed

that the utilization of combined screens in vertical drops increased the subsequent energy dissipation and decreased the relative length of mixing than plain drops. Also, it was observed that by increasing the relative critical depth, the relative wetted length of the vertical screen and the relative length of mixing increases and energy dissipation decreases in the vertical drops equipped by combined screens. However, the evaluation of energy dissipation induced by different components showed that the vertical drop and horizontal screen dissipate more than 82% of the total energy of the system.

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