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Optimal design of stepped spillways using the HBMO algorithm

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Studies on stepped spillways as flood energy dissipators have been conducted to understand the hydraulics on the stepped face of roller-compacted concrete dams as well as overlays of embankment dams. Significant energy losses occur along the stepped chute so that the energy dissipation structure becomes smaller and more economic. In addition, considering the design discharge, downstream face slope, height of spillway, different combinations of spillway width and number of spillway steps may lead to different head losses. In each feasible combination, the remaining head after the steps should be dissipated by downstream energy dissipators. Design and construction of spillways and energy disspators are very cost-consuming and build up a major part of the dam's construction expenses. Thus, the cost of a financially viable stepped spillway project that consists of the steps' cost and downstream dissipator's cost should be minimised. In this paper, the honey-bee mating optimisation (HBMO) algorithm is used to determine the best combination of design variables so as to minimise the total cost of both spillway chute and stilling basin. Results are compared with those previously obtained by genetic algorithm (GA) and show the promising potential of the HBMO algorithm in this field of application.

Keywords: honey-bee mating optimisation (HBMO) algorithm; stepped spillway; optimum design

1. Introduction

Interest in stepped spillways is still growing, because of their cost-efficient construction method. In principle, a stepped chute dissipates more energy than a smooth chute. A stepped-chute design significantly increases the rate of energy dissipation taking place along the spillway face, and eliminates or reduces greatly the need for a large energy dissipator at the toe of the chute, hence cutting down the cost of the downstream stilling basin at the end of the spillway (Matos 2000). A stepped chute consists of an open channel with a series of drops in the invert. The unit flow discharge in these spillways compared with the smooth spillway chutes is smaller and limited in order to prevent cavitation damage. A large air entrainment rate also significantly decreases cavitation risk along the spillway (Rajaratnam 1990). For some site conditions, however, construction of wide chutes for decreasing the discharge rate is not allowed.

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