Field investigations of hydraulic jumps in natural channels with discrepancy corrections for experimental-based formulations

Maisnam Bipinchandra Singh*, Ngangbam Romeji and Thiyam Tamphasana Devi

Civil Engineering Department, National Institute of Technology Manipur, Imphal 795 004, India

The phenomenon of hydraulic jumps has been widely studied in laboratory flumes. However, few studies have been made to bridge the discrepancy encountered in the formulation of relations ascribing hydraulic jumps based on laboratory model studies and that occur in natural conditions. Most of the predictive formulae for sequent depth ratio and length of jump proposed in the literature have not been verified in the field. The present study attempts to link the field investigation data of hydraulic jump in a weir with laboratory channel flume observation for similar flow conditions. The hydraulic jump parameters were collected in the field using feasible technologies in the study weir. The weir selected for this study has geometric, kinematic and Froude similarities with the laboratory model. The comparison of laboratory model data and field measurements showed inconsistency. It is observed that the sequent depth ratio and length of the jump are inaccurately predicted by the laboratory relation compared to the field observations by the laboratory relation. A field-validated-based relationship is suggested for the calculation of sequent depth and length of jump in a smooth rectangular channel for Froude numbers ranging from 4 to 10.

Keywords: Hydraulic jump, length of jump, natural channels, sequent depth ratio.

channels pose constraints. Studies have been mostly conducted using numerical simulations and laboratory-based investigations. The stream will move either upstream or downstream depending upon the geometry of the pool at a particular time step within a limited distance step[1].

Early studies conducted in rectangular, horizontal smooth-walled channels[2], the application of momentum principles led to the development of Bélanger's well-known equation. This equation assumes uniform velocity and hydrostatic pressure distributions both upstream and downstream of the hydraulic jump, with negligible boundary flow resistance. However, subsequent research by Harleman[3] revealed that the sequent depth ratio values are lower for high upstream Froude numbers than what Bélanger's equation predicts. Gill[4] further demonstrated that neglecting channel boundary flow resistance results in an overestimation of the sequent depth ratio. Consequently, alternative methods have been proposed to determine sequent depth values in horizontal, smooth-walled channels. These methods take into account additional parameters, as exemplified by studies by Leutheusser and Kartha[5], and McCorquodale and Khalifa[6].

Furthermore, researchers[2,4] have been conducted studies on sequent depth ratio and length of jump. The length of the hydraulic jumps cannot be determined from theoretical approaches alone. Several researchers[7,8] define the jump