EXPERIMENTAL STUDY OF UNSTEADY TRANSCRITICAL FLOW IN RECTANGULAR CHANNELS

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The occurrence of transcritical or mixed flow, i.e. supercritical and subcritical flow regimes, is considered as a special case in unsteady flow in a channel reach which can clearly be exemplified by a moving hydraulic jump. The occurrence of transcritical flow in field conditions is quite often. There are verity of hydraulic structures such as control gates, weirs and culverts in an irrigation network that generate, accommodate or convey transcritical flow during their normal operation or at a given discharge range. Some complexity is inherent in the numerical analysis of transcritical flow. The main feature of a transcritical flow, which should be paid special attention when modeling this kind of flow, is the directions of wave propagation in sub- and supercritical flow regimes. An appropriate numerical solution to simulate transcritical flow should be able to capture the shock and discontinuity of the flow, to take into account the diversity of the wave propagation and to provide suitable boundary condition applicable to each flow regime. Although, the prismmen numerical scheme is considered a standard one for solving one dimensional open channel flow equations and applicable to sub and supper critical flow regimes separately, It could not be used for the transcritical flow case .Also, published experimental data regarding this kind of flow are scarce and experimental investigations require special laboratory facilities and treatments. In this research an experimental setup was prepared to compile the hydraulic characteristics of transcritical flow in a rectangular flume. The experimental setup consisted of a rectangular tilting flume 9m long, 0.25m wide and 0.5m deep. At the downstream end of the flume a rotating flap tail gate was installed which provided the ability of controlling flow depth within the flume. Water was supplied to the flume entrance by a pipe having control valve which was connected to a large constant head reservoir installed outside the lab. A sluice gate was installed inside the flume at 0.7m distance from its entrance to provide the required condition for generating transcritical flow and measuring the inflow discharge in any second. The water surface elevation at the upstream side of the sluice gate was recorded by means of low head pressure transducer which was connected to a data acquisition system designed for this purpose. During each run the water surface profile along the channel was recorded by using a video recorder. Based on the recorded data, some flow parameters such as flow depth, pressure head and energy head were determined. In addition to the measured unsteady flow parameters such as discharge at the gate position, Q_g, and flow depths directly upstream and downstream of the transcritical flow front, y_{1U} and y_{2U} the steady conjugate depth, y_{2S}, associated with the measured unsteady supercritical flow depth, y_{1U}, was computed based on the well known steady state Blanger equation and included in the tabulation. In this regard the difference between y_{2S} and y_{2U} was distinguished as a main

factor in the analysis of transcritical flow. In this paper the data pertinent to three specific hydrographs were presented and analyzed. The discharge along the supercritical reach at a given moment was considered constant and equals Q_g. However, the discharge at the downstream side of the transcritical flow, Q_U, differs form that of the upstream side, Q_g. Since the magnitude of each term of the general momentum equation has not precisely known, also the backwater effects and the unsteadiness of flow could have impact on the discharge value. The result reveals specific relations between the discharge and moving hydraulic jump parameters. Also, by applying proper assumptions and employing steady state momentum and energy equations simple and time independent relations were obtained, that determines the pressure head in subcritical region of unsteady mixed flow. Consequently, having the discharge variation as upstream boundary condition, one may reliably estimate the unsteady transcritical flow parameter based on time independent relations.