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Hydraulic shock waves in an inclined chute contraction

C.-D. Jan (1) and C.-J. Chang (2)

(1) Department of Hydraulic and Ocean Engineering, National Cheng Kung University, Tainan 70101, Taiwan (cdjan@mail.ncku.edu.tw, 886 6 2741463), (2) Water Resources Agency, Ministry of Economic Affairs, Taichung 40873, Taiwan (a630200@ms1.wra.gov.tw)

A chute contraction is a common structure used in hydraulic engineering for typical reasons such as increase of bottom slope, transition from side channel intakes to tunnel spillways, reduction of chute width due to bridges, transition structures in flood diversion works, among others. One of the significant chute contractions in Taiwan is that used in the Yuanshantzu Flood Diversion Project of Keelung River. The diversion project is designed to divert flood water from upper Keelung River into East Sea with a capasity of 1,310 cubic meters per second for mitigating the flood damage of lower part of Keelung River basin in Northern Taiwan. An inclined chute contraction is used to connect Keelung River and a diversion turnel. The inlet and outlet works of the diversion project is located at Ruifang in the Taipei County of north Taiwan. The diameter of diversion tunnel is 12 meters and the total length of tunnel is 2,484 meters. The diversion project has been completed and successfully executed many times since 2004 to lower the water level of Keelung River in typhoon seasons for avioding flooding problems in the lower part of Keelung River basin. Flow in a chute contraction has complicated flow pattern due to the existence of shock waves in it. A simple and useful calculation procedure for the maximum height and its position of shock waves is essentially needed for the preliminary design stage of a chute contraction. Hydraulic shock waves in an inclined chute contraction were experimentally and numerically investigated in this study with the consideration of the effects of sidewall deflection angle, bottom inclination angle and Froude number of approaching flow. The flow pattern of hydraulic shock waves in a chute contraction was observed. The main issue of designing chute contraction is to estimate the height and position of maximum shock wave for the consideration of freeboards. Achieving this aim, the experimental data are adopted and analyzed for the shock angle, the height of maximum shock wave and the corresponding position of maximum shock wave. The dimensionless relations for the shock angle, the height of maximum shock wave and the corresponding position of maximum shock wave are obtained by regression analysis. These empirical regression relations, basically relating to the sidewall deflection angle, bottom angle and approach Froude number, are very useful for further practical engineering applications in chute contraction design for avoiding flow overtopping.