Proceedings of the 11th International Conference on Fluid Flow, Heat and Mass Transfer (FFHMT 2024)
Chestnut Conference Centre - University of Toronto, Toronto, Canada – June 16-18, 2024
Paper No. 032
DOI: 10.11159/ffhmt24.032

Open-channel Flow in a Narrow Channel behind a Backward-facing Step

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Extended Abstract

Backward-facing step (BFS) flow is a phenomenon with far-reaching implications in many applications such as diffusers, combustors, turbines, aircraft, vehicles, and buildings. The phenomenon also features in open and closed duct and drainage systems that have sudden expansions in the path of flow. While extensive research efforts have been dedicated to investigate BFS flows, cases associated with narrow channels are relatively few [1, 2]. In this work, we examine the detailed turbulent flow field of in a narrow open-channel to understand the effects of expansion ratio and Reynolds number variations.

The physical flow is modelled in an experimental facility consisting of a channel flume with a backward-facing step of height *h* installed in the upstream section of the flow. With such an arrangement having an aspect ratio of 4, a narrow BFS flow system was achieved. By varying the flow depth for different test cases, BFS flows of expansion ratio (ER) ranging from 1.25 to 1.50 were tested. Additionally, open-channel turbulent flow was conducted through the flume at various flow rates such that the Reynolds number (Re) based on *h* and the maximum velocity was between 3000 and 11,000. A planar particle image velocimetry technique was used to capture relative flow and geometric effects around the recirculation region of the flow.

As expected, the mean streamwise velocity data for all cases show the existence of a recirculation region just behind the step. However, increasing Re by nearly two-fold leads to the clear development of a multi-centred primary recirculation bubble, and a secondary corner bubble. Regardless of these significant changes, the reattachment length is fairly constant. Further increment of the Re leads to an elimination of the corner bubble, such that the separated flow is marked by a single bubble with a clear centre. By increasing Re and ER by 50% and 20% respectively, the reattachment length is enhanced by 16%. The turbulent flow, on the other hand, suggests turbulent intensities and turbulent kinetic energy influenced primarily by Re.

Overall, these results suggest important differences between closed-channel and open-channel BFS flows [3]. The combined influence of ER and Re are significant compared with any single effect of ER and Re. This study not only contributes to a better understanding of BFS flow but also provides valuable insights into the optimization BFS configurations in hydraulic engineering to obtain energy-efficient arrangements.

References

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