

Preface

The computation of unsteady free surface flows has an important place in disciplines such as civil, environmental, and coastal engineering, given the need to solve real-life problems associated with this fascinating type of hydraulic motion. During the past decades, their three-dimensional (3D) computation using RANS and LES models gained impulse, permitting an accurate numerical solution of complex hydraulic flows. These numerical solutions are usually coupled in a hybrid way with physical laboratory experimentation. Given that 3D numerical solutions are still time-consuming and computationally costly, the common mathematical tool for simulating unsteady free surface flows still relies on the use of depth-averaged 2D models. This approach is popular among water scientists and hydraulic engineers, given that the 2D depth-averaged mathematical formulation and numerical implementation are simpler. The standard 2D approach is based on the Saint–Venant hydrostatic theory for flows in a horizontal plane, which is by now powerfully solved using modern shock-capturing methods like the finite volume method or the discontinuous method of Galerkin. However, there are a number of important real-life hydraulic flows that are not suitable for modelling based on the hydrostatic pressure approach, including flows over control structures, such as a dam crest, the bed-form evolution in alluvial rivers, the drainage of recharge in aquifers, or the avalanche mass flows down a steep mountain.

Furthermore, the teaching of free surface flows all over the world strongly relies on the seminal books of Ven Te Chow (published in 1959) and Francis M. Henderson (published in 1966), in which the Saint–Venant theory is lucidly explained and applied. Most of the (few) open-channel books written since expanded and presented in detail the theory of Saint–Venant. However, non-hydrostatic flow problems are often only mentioned without details on the procedures available. They are in most cases referred to papers or explained based on dimensional analysis and experimentation. Advanced depth-averaged modeling approximations, and the power of their possibilities in engineering, are hardly available in open-channel flow books.

Despite the interest of the non-hydrostatic theory for teaching, research, and practice, the only book so far written on that topic is Boussinesq's "*Essai sur la théorie des eaux courantes*," published in 1877. This is indeed the original book in which Boussinesq masterly presented his depth-averaged theory. Today, almost 140 years since, the purpose of this new book is to fill in the gap by presenting the higher mathematical level of approximation over the Saint-Venant hydrostatic theory, also referred to as the Boussinesq theory, and the advances since Boussinesq's book. The theory and computation of non-hydrostatic free surface flow problems using depth-averaged models are developed, including problems in open channels (inviscid and viscous), groundwater with a phreatic surface, and granular material. The application of the theory to coastal engineering problems is beyond the scope of the book. However, the main advances on the use of Boussinesq-type models in this discipline are considered at adequate places by using the theoretical developments presented here.

The book topic coverage originates from the collaborative work of the authors, working toward the solution of these problems during the past ten years. The book was designed to be as complete as possible, with a detailed source of literature references and adequate technical information, so that any interested reader will be ready to deepen into the problems. Worked problems are not presented. Rather, detailed solutions are produced and compared with experimental data to show the performance of the theory. A comparison with other theories is presented when considered adequate and illustrative. Short biographies of pioneers in non-hydrostatic free surface hydraulics are further presented to keep the interest on what others did in the past. A special feature of the book is that mathematical developments are presented step-by-step in great detail. The development of Boussinesq-type equations is sometimes tedious, and algebraic manipulations are difficult to reproduce. This level of detail is usually lacking in papers, and it is fully covered in this work to help young researchers. In addition to the detailed developments included within the text, ten appendices were prepared to further help readers. We envision this book to be of use for Ph.D. students and researchers conducting work on this fascinating field. The material is also adequate for teaching purposes in courses on advanced open-channel flow for master students in civil and environmental engineering.

Cordoba, Spain
Zürich, Switzerland
April 2017

Oscar Castro-Orgaz
Willi H. Hager

Non-Hydrostatic Free Surface Flows

Castro-Orgaz, O.; HAGER, W.H.

2017, XVI, 696 p. 230 illus., 17 illus. in color., Hardcover

ISBN: 978-3-319-47969-9