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BOOK REVIEW

Mécanique des Fluides Appliquée. By P. L. Viollet, J. P. Chabard, P. Esposito & D. Laurence. Presse des Ponts et Chaussées, 1998. 367 pp. ISBN 2 85978 301 6.

This book, which is written in French, deals with incompressible flows in fluid mechanical devices (pumps etc.), channels and rivers, around structures, and in the environment. The topics selected cover most of the needs of the hydraulic and civil engineering community, for whom this book is intended. The material is organized into seven chapters of varying length.

The Introduction starts with a (perhaps too) lengthy historical perspective (23 of its 66 pages) before proceeding to the field equations in integral form. The Navier–Stokes equations for the restricted case of an incompressible fluid are deduced in only a few pages, without any discussion of the boundary conditions that are required. Hence the reader is expected to have some previous knowledge of continuum mechanics. It might have been better to make the text self-contained by replacing part of the historical perspective with this necessary background material. The domain of validity of the incompressible assumption is discussed briefly in terms that are rather approximate: 'An incompressible flow [correctly defined by its isochoric character] is a flow where it is possible to assume that the density is constant'; and the Boussinesq approximation is never mentioned even though temperature variations are permitted. In the following pages classical fluid mechanics concepts are introduced (irrotational flows, free-surface conditions, boundary layers) but with few useful explanations (for example, boundary layers are 'parachuted' in without their boundary conditions or discussion of their matching with inviscid flow), and with several loosely worded sentences like 'an incompressible flow problem is independent of gravity if boundary conditions do not involve pressure'. Turbulence is introduced in § 3; and dimensional analysis in § 4. Strangely, earlier the Navier–Stokes equations were not discussed in terms of non-dimensional quantities except that, in solving the Blasius flow problem on a flat plate in § 3, the Reynolds number is mentioned in passing.

Chapter 2 (69 pages long) which deals with turbulence and turbulent flow modelling, is a good and concise engineering introduction to these topics. The important points concerning the closure problem and the classical turbulence models are put forward well, with good summarizing discussions of models up to second moments, and some examples. However, the reader will again notice some inaccuracies, the most important being the definition of turbulent homogeneous flow as one having uniform means, rather than having translational invariance of means (so that the mean velocity may be linear with respect to the coordinates).

Chapter 3 (28 pages) starts with Poiseuille flow and the definition of head, before considering turbulent channel and pipe flows. The statement that the pipe flow and channel flow problems are not equivalent because the equations 'do not allow one to define, as in the plane channel, a dynamic pressure that would be uniform in one section' can be considered erroneous (see Tennekes & Lumley 1972). Moreover, equation (3.12) lacks a normal turbulent azimuthal contribution. Finally, head losses are dealt with in a standard way.

Chapter 4, 29 pages long, concerns forces induced by flow past bodies. After a short introduction to the physics and aerodynamic force coefficients, the momentum theorem is used to compute the steady forces exerted by the flow on a body. The distinction between 'streamlined' (§ 2.1) and 'bluff' (§ 2.2) bodies lacks clarity. The former seem to be related to slender bodies oriented orthogonally to the flow (or two-dimensional bodies), but the two- and three-dimensional cases are not distinguished: the Green's function for the far field is not the same in both cases, while the velocity perturbation is stated incorrectly to be proportional to R^{-3} in both cases. Moreover, it is the evolution of the flux that is important (the product of normal velocity and area). The evaluation of forces acting on a two-dimensional airfoil involves a rectangular contour, Σ, surrounding the airfoil. Denote by Σ' the downstream part of the contour, where it cuts the wake, so that $\Sigma - \Sigma'$ is of inviscid character. Equation (4.21) then cannot be understood: it is incorrectly stated that the Σ' surface does not contribute to lift. Lift is determined from equation (4.24) in all cases in terms of the circulation, Γ. However, for viscous flows Γ is evaluated along the *infinite far-field* contour, whereas the contour Σ is arbitrary for potential flow. The best discussion of forces is still that by Lagerstrom in the classic book *Theory of Laminar Flows* (1964). The second case, 'bluff' bodies, seems to involve axisymmetric bodies (as indicated by the $x^{1/3}$ evolution of the wake thickness; the $x^{1/2}$ planar case is not mentioned). Finally, the added-mass concept is introduced in a standard way, assuming irrotational flow.

Chapter 5 deals with geophysical and free-surface flows (41 pages). In §1 the geostropic approximation is introduced for quasi-horizontal flows, followed by a description of the atmospheric boundary layer. The Ekman layer is presented as a zone of the atmospheric boundary layer rather than as a boundary layer required to satisfy the no-slip condition not allowed by geostrophic flow. Free-surface flows in shallow water are then treated and the Saint Venant equations established. It is unfortunate that classical dynamic and kinematic free-surface conditions are not introduced and discussed within the framework of the Navier–Stokes equations.

The (x, t) form of the Saint Venant equations is treated in Chapter 6 (77 pages on unsteady flows in channels and rivers) by the method of characteristics, primarily as a means to present simple properties of free-surface flows, like waves, hydraulic jumps and other problems connected with river beds and dams.

The final Chapter, 7 (37 pages), concerns steady flows and sediment transport in channels and rivers. Free-surface channel flows are briefly reviewed, with a much appreciated emphasis on secondary flows. Even more relevant to the subject are the pages devoted to sediment transport. Finally, flow regimes for steady flows with reference to the Saint Venant equations are introduced (which are useless for the prediction of secondary flows in rivers and channels).

One of the strong points of the book is that each chapter ends with well-chosen problems with detailed solutions. The illustrations and examples of applications from fluid mechanics computations (often performed with software from EDF where the authors work) are very welcome and add to the presentation. The topics selected, which are generally well-chosen, are a good reflection of the preoccupations of modern hydraulics professionals. The comprehensive introduction to turbulence at an early stage in the book is also a good point, with its focus on Navier–Stokes solutions for turbulence models (such models could be used with Navier–Stokes solvers for beds and rivers to predict secondary flows, although this is seldom done).

A weakness of the book is that trends in new understanding of the topics covered are rarely indicated, nor is the advance of CFD in hydraulics and civil engineering; these would in fact make some of the material covered out of date. This, together with the numerous inaccuracies and misinterpretations, detract from the value of this book, and I cannot strongly recommend it.

REFERENCES

LAGERSTROM, P. A. 1964 In *Theory of Laminar Flow* (ed. F. K. Moore). Princeton University Press.
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