FLUID MECHANICS EDUCATION, NATURAL HAZARDS AND THE CARIBBEAN

Gyan Shrivastava[*a)]
[*]*Department of Civil Engineering,*
University of the West Indies, St. Augustine, Trinidad, West Indies

Summary, Fluid Mechanics Education for the undergraduate civil engineering students, for the Islands of the Commonwealth Caribbean, is influenced by the need for a robust design of infrastructure for withstanding the forces of nature associated with hurricanes, storm surges, and tsunamis. Against the foregoing background, this paper describes the Fluid Mechanics Education in the Department of Civil of Engineering at the University of the West Indies.

INTRODUCTION

Fluid Mechanics forms the theoretical base for coastal, environmental and hydraulic engineering and plays a critical role in the design of civil engineering infrastructure. With specific reference to the Commonwealth Caribbean islands, there is a need for protection of critical lifeline infrastructure from high winds and storm surges during the frequent passage of hurricanes. Moreover, these islands are also vulnerable to tsunamis, and there is a need for the construction of tsunami shelters. It should also be noted that most of these islands have a mountainous terrain, and that the major roads, urban areas, airports, water pipelines and hotels are located along the coastline. Therefore, a clear and deep understanding of fluid mechanics is essential for the wind resistant design of buildings and wave resistant design of coastal roads, breakwaters, pipelines, sea walls, shoreline revetments and tsunami shelters. This short paper provides a glimpse of fluid mechanics education for civil engineering students at the University of the West Indies.

The University of the West Indies (UWI)

UWI has four campuses - in the Bahamas, Jamaica, Barbados and Trinidad – across the Caribbean Region (Figure 1). It is an autonomous regional institution and currently has a total enrolment of approximately 40,000 students. It started as Imperial College of Tropical Agriculture of the University of London in 1948 and at present is supported by, and serves, the following 17 islands: Anguilla, Antigua and Barbuda, the Bahamas, Barbados, Bermuda, the British Virgin Islands, the Cayman Islands, Dominica, Grenada, Jamaica, Montserrat, St. Kitts, Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Turks and Caicos Islands. These islands have a combined population of about 5 million people, a total land mass of approximately33,000 km^2, and are spread over an oceanic area of approximately $2.25x10^6$ km^2.

The Department of Civil Engineering, which is a part of the UWI Faculty of Engineering, is located at St. Augustine in Trinidad. Its undergraduate programme in Civil Engineering commenced in 1961 in a special relationship with Imperial College, London. Moreover, the Department has maintained academic links with the United Kingdom through a formal accreditation of its programmes by with the UK Engineering Council through the Joint Board of Moderators (JBM), which comprises the UK based Institutions of Civil, Structural and Highway Engineers.

Figure 1: The Caribbean

a) Corresponding author. Email: Gyan.Shrivastava@sta.uwi.edu

FLUID MECHANICS EDUCATION FOR NATURAL HAZARDS MITIGATION

The central objective of striving for a clear, and deep, understanding of Fluid Mechanics among the undergraduate students is to develop an ability for correctly, and fully, interpreting the codes of practice/design guidelines relating to wind/structure and wave/structure interactions for the design of hazard resistant infrastructure. At the UWI this objective is achieved through a specially designed syllabi and a continuous learning thread, which puts the fluid mechanics education at the centre of the relevant issues, as shown in Figure 2.

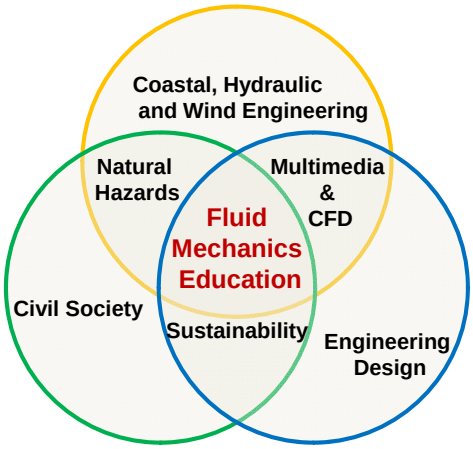

Figure 2: Fluid Mechanics Education for Natural Hazards Mitigation

Acknowledgements

The author is grateful to the late Professor J. R. D. Francis at Imperial College, London, UK, for creating in him a lifelong interest in Fluid Mechanics.

References

[1] Cengel, Y. A. and Cimbala, J. M.: Fluid Mechanics: Fundamentals and Applications. McGraw-Hill, NY 2006.

[2] Homsby, G. M., (ed): Multi-Media Fluid Mechanics, DVD-ROM. Cambridge University Press, 2008.

[3] Massey, B. S.: Mechanics of Fluids, Stanley Thornes, 1998.

[4] Van Dyke, M.: An Album of Fluid Motion. Parabolic Press, 1982.

Learning Thread

The learning thread in Fluid Mechanics for the undergraduate civil engineering students begins with an introductory course in Fluid Mechanics in their first year. In this course, principles of hydrostatics, the conservation laws of mass, energy and momentum and their applications are first introduced. These are followed by an introduction to boundary layers. In the second year, the students take another course in Fluid Mechanics which concentrates on flow in open channels, potential flow and atmospheric boundary layer. Thereafter, in the third year, the students take a course in Coastal Engineering where mechanics of wave motion, sediment transport and design of coastal structures are covered. Finally, all undergraduate students are required to carry out a final year capstone design project which - given the oceanic setting of the Commonwealth Caribbean - invariably requires consideration of wind and wave forces. The capstone design project, *inter alia*, requires, and develops, skills of analysis and synthesis, and in it the students come to appreciate the need for clarity, and depth, of their knowledge in Fluid Mechanics for correctly interpreting the physical processes involved as well as the various codes of practice and guidelines mentioned earlier. A clear and deep understanding leads to optimal design and construction of infrastructure, and thus enhances its sustainability.

The aforementioned learning thread is underpinned by closely supervised tutorial sessions, site visits, laboratory experiments, text and reference books, multimedia and Computational Fluid Dynamics (CFD. It is said that those of us who teach fluid mechanics are fortunate, as are our colleagues in some other fields such as optics, that our subject is easily visualized. Moreover, the literature of fluid mechanics has many beautiful and revealing photographs which can be used as a valuable resource for teaching. Thus, the text book by Massey [3] is supplemented by “An Album of Fluid Motion” by Van Dyke [4]. Moreover, the advantages of the aforementioned visual nature of Fluid Mechanics, in the learning process, are further strengthened by the use of an interactive multimedia DVD [2]; which can also be used for carrying out virtual experiments and simulations for improving the clarity of understanding.

Integration of Computational Fluid Dynamics (CFD) in the undergraduate fluid mechanics courses can considerably enhance learning [1]. Specifically, classroom CFD demonstrations and home assignments help students to learn the basic concepts of Fluid Mechanics. Moreover, it also shows CFD simulations as a powerful design tool for examining alternative designs. It should be noted, however, that only simple applications of CFD, rather than numerical algorithms, are emphasized, e.g. flow separation around a bluff body.

CONCLUSIONS

Fluid Mechanics Education, for Civil Engineers, in the Commonwealth Caribbean islands needs to specifically address, with clarity and depth, its role in the sustainable design of infrastructure for withstanding the fluid dynamic forces associated with hurricanes, storm surges, and tsunamis. This objective is achieved at UWI through: (a) a specially designed syllabi, and (b) the concurrent use of traditional lectures, tutorials and site visits as well as use of multimedia and CFD in a learning thread through its undergraduate civil engineering curriculum.