

Chapter 1

Introduction

The flow over a surface-mounted prism has been used as a generic flow to simulate wind flows around low-rise structures, ship superstructure airwakes and other flows around bluff bodies. Although it is a generic flow, the flow around a surface-mounted prism is very complex. The complexity arises from the separation region on top, the wake behind the prism, and the turbulent fluctuations associated with these regions and their inherent unsteadiness. The applications as well as the complexities present in this flow have led to extensive studies of its characteristics. These studies have dealt with a wide range of characteristics covering macroscopic aspects such as drag and lift forces, mean velocity field and microscopic aspects such as pressure coefficients at different locations, unsteady features, and the stability of the separating layers.

With all the advancements made, simulating the turbulent flow, in particular its unsteady nature, around a surface-mounted prism at high Reynolds number remains expensive. Moreover, it is impossible to obtain a real-time simulation of such a flow. The reason being that using Direct Numerical Simulation (DNS) or Large Eddy Simulation (LES) requires large computer memory and CPU time. On the other hand, one would like to have a real-time simulation, especially if the fluid flow is to be coupled with a bluff-body motion or response.

An alternative approach to simulating the unsteady characteristics of the inviscid flow around a surface-mounted prism is vorticity modeling. Vorticity modeling refers to simulating the solid surfaces of the prism by vorticity sheets of varying strengths. In

addition, the vorticity generated in the boundary layer and shed into the flow at the corners where separation occurs is modeled by the introduction of discrete vortices. Of course, one should not expect that a simulation of the vorticity as explained here to be totally equivalent to one simulation obtained with DNS or LES. However, one would expect that flow effects determined by the inviscid region to be well determined. The motivation for simulating such a complex and unsteady flow with vorticity modeling is that such modeling requires much less computer resources than DNS or LES.

In this work, we present a two-dimensional simulation with vorticity modeling of the flow-field over a surface-mounted prism. The objective is to characterize surface pressure fluctuations associated with the inviscid region of the flow. In chapter 2, we present some engineering applications that are related to the flow over surface-mounted prisms. We discuss important fluid-flow characteristics encountered in these applications. We also point out flow specifics that are of interest. In chapter 3, we review the different simulation techniques with the purpose of showing the requirements and expected results from these techniques and explain what flow components or characteristics are considered by vorticity modeling. In chapter 4, vorticity modeling is performed on a surface-mounted two-dimensional prism. We give details for the numerical simulation steps and discuss the results. In chapter 5, we present a summary and conclusions of this work.