Chapter 1

Introduction

Prediction of wind loads on low-rise structures is important to minimize human and economic losses caused by severe storms, hurricanes, tornadoes, etc. In the United States, losses caused by such events are the most costly among all natural hazards, which include earthquakes, volcanoes, expansive soil and river floods. The estimated annual losses due to wind events exceed five billion dollars [National Weather Services, 1992]. In addition, the number of persons killed by wind events averages approximately 350 per year [Gaus, 1985], which is more than deaths caused by other disasters. As more people move into hurricane prom coastal areas, one would expect these losses to increase significantly. Among buildings and other structures, prescriptive designed low-rise structures are especially vulnerable to high winds. This is mostly due to the fact that, such structures are usually non-engineered.

The first step in attempting to predict wind loads is simulation of the turbulence characteristics of the atmospheric surface layer. These characteristics are usually given in terms of mean flow and turbulence parameters. Yet, one of the most important characteristics of the atmospheric surface layer is the level of variations in such parameters. There is no question that one of the most important parameters to be simulated in relation to wind loads on structures is the Reynolds number based on mean velocity and on the characteristic building dimension. However, due to geometric limitations and power requirements, it is almost impossible to simulate the Reynolds number in a wind tunnel. The failure to simulate the mean flow Reynolds number causes many problems related to simulating the turbulence characteristics. The turbulence characteristics are usually represented in terms of statistical and spectral parameters. These parameters include turbulence intensities, integral length scales, large- and small- scale turbulence, aerodynamic roughness, and spectra of velocity components of the wind.

To date, based on several studies, one can conclude the following as far as predictions of pressure loads on low-rise structures. When the wind tunnel simulation is well matched in terms of mean flow properties and longitudinal turbulence intensity, mean pressures compare reasonably well in most cases. On the other hand, large discrepancies exist when comparing extreme negative pressure coefficients from wind tunnel experiments with those observed in full scale measurements. Recent studies of Tieleman [1994] strongly suggest that, the simulation of lateral turbulence intensity is also important in terms of prediction of peak pressure events. One important variable that is not well represented in the parameters used for wind tunnel simulation of atmospheric turbulence are its time-varying characteristics. Parameters such as turbulence intensities, integral scales, aerodynamic roughness, and spectra are all averaged over long periods of time. As a result, important information on the time varying characteristics is not well represented in such parameters. Such characteristics are important because the pressure peaks to be simulated usually last for few seconds. Janajreh [1998] proposed using intermittency parameters to characterize short time intense fluctuations. Janajreh also showed that, there is a relation between, high-intensity events in the velocity components of the atmospheric surface layer and the pressure peaks observed in the field measurements at the Wind Engineering Research Field Laboratory (WERFL) at Texas Tech. These results show that parameters based on time-varying characteristics need to be simulated in order to simulate or predict peak pressures on low-rise structures.

In this work, we use the same analysis and parameters proposed by Janajreh to determine how the time-varying characteristics can be simulated in a wind tunnel. The wind tunnel at Clemson University is a boundary layer tunnel, where different floor roughness configurations can be set up by introducing various spires, tripping elements, baffles, roughness elements and etc. Othonormal wavelets, as proposed by Janajreh, will be applied to measured velocity time histories to obtain intermittency parameters. In chapter 2, we present how different configurations were established in the Clemson wind tunnel. In chapter 3, time-averaged simulation parameters from different configurations are discussed. In chapter 4, orthonomal wavelets are applied to determine the intermittency parameters. In chapter 5, pressure characteristics for the different configurations are presented. The work presented here has three main contributions. First, it improves the methodology for assessment of turbulence characteristics in wind tunnel by providing information of intermittency, which can not be obtained from any of the previous approaches. Second, it provides sufficient evidence and proves the methodology of manipulating turbulent energy distribution and their intermittency behavior by using different spires and other roughness elements to construct floor roughness the configurations. Third, it provides effective and reliable parameters to compare turbulence generated from wind tunnel with that obtained from full-scale experiments. This could help us to find out the best wind tunnel simulation to atmosphere turbulence among all configurations.