5.3. ESTIMATION OF THE FREQUENCY AND DAMPING OF BUILDINGS

The frequency and damping of the building are the two key parameters required to calculate wind loads. Typically, the computer models of buildings provide the natural frequencies. However, during the preliminary design stages, there is a need to know the frequency and damping of the building to complete the design and develop the computer model. The latest ASCE Standard, ASCE 7-05, provides some empirical equations and guidelines to predict the frequency and damping for preliminary design [8].

6. CALCULATION OF MAXIMUM ACCELERATIONS

Wind design is based on maximum displacements, which are calculated by applying the forces discussed above as static loads to the structure. In some cases, maximum accelerations are also needed for the design of the structure (e.g., to check the possibility of human discomfort in tall, flexible buildings). This requires a more detailed dynamic analysis. Since dynamic wind loads are defined statistically (i.e., in terms of the power spectral density function of gust), the analysis requires the application of the Random Vibration Theory.
There are approximate methods that can also be used to estimate accelerations from the gust loading factor approach presented in this document (e.g., Refs. 9 and 10). A full dynamic analysis for wind loads should be made under the guidance of an expert who are familiar with the theory and practice. A dynamic wind tunnel test can be a substitute for any dynamic analysis.

7. ACROSS-WIND RESPONSE OF BUILDINGS

When wind pass through tall and flexible buildings, vortices develop on the sides and the back of the building as schematically shown in Fig. 7.1 below. Since the development of vortices on side faces alternate (i.e., they develop first on one side and then the other side), the direction of vortex-shedding forces also alternate, creating vibrations in the direction perpendicular to the main wind flow. If the frequency of vortex shedding forces is close to one of the natural frequencies of the structure, the amplitudes of vortex-induced oscillations can reach to values that are much larger than those of the oscillations in the along-wind direction. The wind speed at which the maximum cross-wind response occurs is known as the critical wind speed, V_{cr} .

Both narrow-band and broad-band responses can develp due to vortex shedding. At small amplitudes, the response is broad-band . When the oscillations become large, the vortex-shedding frequency locks in to the nearest natural frequency of the structure, creating constant-amplitude and narrow-band (i.e., almost sinusoidal) oscillations over a range of wind speeds. Sometimes, a combination of both forms of response occurs. The oscillations change from being small and random to being sinusoidal and large over irregular time periods.

Galloping is another flow phenomenon that can cause across-wind vibrations and often occurs coincidently with vortex shedding. Galloping is the self-excited vibrations due the motion of the structure in the wind, and developes above a critical value of wind velocity. It is basically a structural instability phenomenon that can initiate in low turbulance levels and at frequencies lower than that of vortex shedding.