C10.4.6 Design Ice Thickness for Freezing Rain

The design load on the structure is a product of the nominal design load and the load factors specified in Chapter 2. The load factors for load and resistance factor design (LRFD) design for atmospheric icing are 1.0. This is similar to the practice followed in this standard for seismic loads. Figs. 10-2 through 10-6 show the 50-yr mean recurrence interval ice thickness due to freezing rain and the concurrent wind speeds. The probability of exceeding the 50-yr event in 50 years of a structure's life is 64 percent. The design wind loads in this standard (nominal loads times the load factors in Chapter 2) have a mean recurrence interval of approximately 500 years, which reduces the probability of being exceeded to approximately 10 percent in 50 years. Consistent with the design wind loads, the design level mean recurrence interval for atmospheric ice loads on ordinary structures, including load factors, is approximately 500 years. Table C10-1 shows the multipliers on the 50-yr mean recurrence interval ice thickness and concurrent wind speed to adjust to other mean recurrence intervals.

The factor 2.0 in Eq. 10-5 is to adjust the design ice thickness from a 50-yr mean recurrence interval to a 500-yr mean recurrence interval. The multiplier is applied on the ice thickness rather than on the ice load because the ice load from Eq. 10-1 depends on the diameter of the circumscribing cylinder as well as the design ice thickness. The studies of ice accretion on which the maps are based indicate that the concurrent wind speed on ice does not increase with mean recurrence interval (see Section C10.4.4).

When the reliability of a system of structures or one interconnected structure of large extent is important, spatial effects should also be considered. All of the cellular telephone antenna structures that serve a state or a metropolitan area could be considered to be a system of structures. Long overhead electric transmission lines and communications lines are examples of large interconnected structures. Figs. 10-2 through 10-6 are for ice loads appropriate for a single structure of small areal extent. Large interconnected structures and systems of structures are hit by icing storms more frequently than a single structure. The frequency of occurrence increases with the area encompassed or the linear extent. To obtain equal risks of exceeding the design load in the same icing climate, the individual structures forming the system or the large interconnected structure should be designed for a larger ice load than a single structure.

Several studies of the spatial effects of ice storms and wind storms have been published. Golikova et al. (1982) present a simple approach for determining the risk of ice storms to extended systems compared to single structures. The results indicate that the mean recurrence interval of a given ice load for a transmission line decreases as the ratio of the line length to the ice storm width increases. For a line length to storm width ratio of 2, for example, the mean recurrence interval of a 50-yr load as experienced by a single tower will be reduced to 17 years for the entire line. In another study, Laflamme and Periard (1996) analyzed the maximum annual ice thickness from triads of passive ice meters spaced about 50 km apart. The 50-yr ice thicknesses obtained by extreme value analysis of the triad maxima averaged 10 percent higher than those for the single stations.

C10.5 WIND ON ICE-COVERED STRUCTURES

Ice accretions on structures change the structure's wind drag coefficients. The ice accretions tend to round sharp edges reducing the drag coefficient for such members as angles and bars. Natural ice accretions can be irregular in shape with an uneven distribution of ice around the object on which the ice has accreted. The shape varies from storm to storm and from place to place within a storm. The actual projected area of a glaze ice accretion may be larger than that obtained by assuming a uniform ice thickness.

C10.5.5 Wind on Ice-Covered Guys and Cables

There is practically no published experimental data giving the force coefficients for ice-covered guys and cables. There have been many studies of the force coefficient for cylinders without ice. The force coefficient varies with the surface roughness and the Reynolds number. At subcritical Reynolds numbers, both smooth and rough cylinders have force coefficients of approximately 1.2 as do square sections with rounded edges (Fig. 4.5.5 in Simiu and Scanlan 1996). For a wide variety of stranded electrical transmission cables the supercritical force coefficients are approximately 1.0 with subcritical values as high as 1.3 (Fig. 5-2 in Shan 1997). The transition from subcritical to supercritical depends on the surface characteristics and takes place over a wide range of Reynolds numbers. For the stranded cables described in Shan (1997) the range is from approximately 25,000 to 150,000. For a square section with rounded edges, the transition takes place at a Reynolds number of approximately 800,000 (White 1999). The concurrent 3-s gust wind speed in Figs. 10-2 through 10-5 for the contiguous 48 states varies from 30 to 60 mi/h