WIND-INDUCED VIBRATION OF LONG-SPAN ROOF STRUCTURES WITH A DOMINANT OPENING

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Abstract- The buildings with long-span roofs are widely utilized for industry as well as public events. In general, the long-span roof structures are more sensitive to winds than to earthquakes, because they are light and flexible. Moreover, wind-induced vibration of the roof structures of the normally sealed buildings may become much more significant, when there are some dominant openings due to broken doors and/or windows in high winds. It has been well recognized in practice that high internal pressure induced through the openings is one of the major reasons of building (roof) damages during strong winds. In this paper, we present an analytical method for the study on wind-induced vibration of long-span roof structures with a single (lumped) dominant opening. The walls of a building are assumed to be rigid so that they do not deform even subjected to external loads, while its (long-span) roof is flexible. Ignoring background leakage, the analysis model is a generalized multi-degree-of-freedom (MDOF) dynamic system. The system consists of an air slug in the dominant opening and the vibration modes of the roof resulting in volume change. It is notable here that we consider only the coupling effects between the external pressures of the dominant opening and the internal pressure inside the building, and we insist that the external pressures on the roof do not affect the internal pressure. Moreover, distribution of internal pressure is assumed to be spatially uniform inside the building. Using the existing wind tunnel test results of a simplified system with a single opening and a rigid roof, we first verify the validity of the single-degree-of-freedom (SDOF) dynamic system. In the SDOF system, only the displacement of the air slug is considered, and it is in fact a reduced version of the proposed MDOF system. Theoretical study on the two-DOF system with only the first vibration mode of the roof shows that the Helmholtz resonance frequency is reduced with increasing roof flexibility. Moreover, numerical simulations of the MDOF system demonstrates that existence of the dominant opening may greatly increase dynamic responses of the roof due to the high variation of internal pressure. This effect should be considered in the structural design, especially in the high wind regions.

Keywords- Wind-induced vibration, Long-span, Roof, Dominant opening, Analytical method, Internal pressure