Modeling the Internal Pressure Response of Typical Buildings to Tornado-Induced Wind Loading

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This study evaluates the impact of the atmospheric pressure deficit (APD) within tornado-like vortices on the structural wind loads on low-rise buildings using experimental and numerical simulation methods. In tornadoes, external pressures represent the combination of aerodynamic effects of the extreme winds in tornadoes and the atmospheric pressure deficit (APD) produced by the rotating flow. Internal pressure responds to the external pressure primarily as a function of opening sizes and locations, and building volumes. It is unknown to what extent the APD in tornado-like vortices equalizes between the exterior and interior of a building, as a function of building porosity, volume, translation speed of the vortex, and more. The APD may enhance tornado-induced wind loads considerably if it is not fully and rapidly equalized in typical buildings.

Internal and external pressure was measured experimentally in a low-rise gable roof building under tornado-like loading using the translating Tornado Simulator at Iowa State University as previously described in Thampi et al. (2011). The building model was constructed at a geometric scale of 1:75 and configured to represent different combinations of opening conditions (sealed, dominant opening, multiple opening) and building model location relative to the centerline of the tornado path (center or offset from the center by a factor of 1.42 times the radius of the vortex core). The internal volume was scaled to maintain the similarity of the dynamic response of the volume at model scale to that in full scale. Using the measured external pressure distributions and known opening locations and sizes and building volume, internal pressure was also simulated using a system of orifice discharge equations (MDE). Comparisons are made between the measured and numerically simulated transient internal pressure with regards to the potential for a buildup in pressure differential to occur on the structure due to the transient response of the internal pressure to the APD through the openings in the building envelope. The capability of the MDE model to accurately predict the internal pressure under the various opening conditions is explored.

References:

Thampi, H., Dayal, V., & Sarkar, P. P. (2011). Finite element analysis of interaction of tornados with a low-rise timber building. *Journal of Wind Engineering and Industrial Aerodynamics*, *99*(4), 369-377.