Turbulence, Quasi-Steady Theory, and Peak Pressures Under Rooftop Vortices

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Extended Abstract

As part of a five-year study of wind effects on low rise buildings at CSU, a model of the manner in which rooftop vortices cause extreme rooftop suctions had been developed and tested. This paper discusses some of the implications of this model and of the tests done to validate it, including:

- How Cp values below −10 are obtained on the roof surface with maximum wind speeds of only 2.4 times the mean reference wind speed at building height (the vortex amplifies the effects of local flow speed), and what this implies for Cp values below −20 which have been measured at full scale.
- How all scales of turbulence could impact surface pressures (They all have different roles in modifying the vortex shape, stability, location and spin rate).
- Why suction increases towards the roof apex (Rotation speed and vortex stability increase).
- Why suction reaches a peak for wind angles of 60° (Rotation speed increases, stability decreases).
- How quasi-steady theory is able to predict the bi-modal pressure probability distribution seen at taps under the vortex. (It is the result of the rapid transition from zones of low suction to high suction as the vortex moves across the tap).
- Why quasi-steady theory is unable to predict the peak and rms pressures under the vortex (there is hysteresis in the conical vortex formation for wind angles more that 20° from the cornering wind (45°), and there is random vortex strengthening and motion which is not included in Q-S theory that leads to an underestimation of RMS).

Some recommendations for future experimental work are also proffered, including

- The advantages of the use of using a row of taps normal to the roof edge, rather than single taps under the expected vortex location. (It allows the determination of the true peak suction as well as the vortex location.)
- The potential use of wavelet analysis to correlate the time dependent frequency content of turbulence above the vortex with vortex behavior.
- The advantages of large scale and full scale study for capturing the very rapid vortex motion which is not correlated to wind direction changes.

References

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