Effects of Wind Direction on Surface Roughness Parameters

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Abstract

Most extant wind tunnel or computational studies on flows over generic urban surfaces have only considered situations when the wind direction is normal to the salient faces of the obstacles. For example, there is a considerable literature on flows over arrays of rectangular obstacles. Numerous efforts have been made to develop morphological relationships linking the aerodynamic characteristics of the surface to the array's detailed geometry, but usually only for cases in which the faces of all obstacles are aligned similarly. This paper considers first the fundamental issue concerning the effect of a surface which generates not only a drag force (in line with the prevailing wind) but also a cross-stream (lateral) force. Zero values of the latter will usually only occur for the special case of a wind aligned normal to the faces of all obstacles in the array. The implications of non-zero values (e.g. wind turning with height) for both numerical and wind tunnel simulations of such surfaces will be explored. This is followed by some examples of both kinds of simulations for the common case of a surface comprising a 25% area coverage of identical cubes, but for various prevailing wind directions, ϕ. It is shown that large differences in drag, and thus roughness length occur as ϕ varies and that the lateral force can be significant.

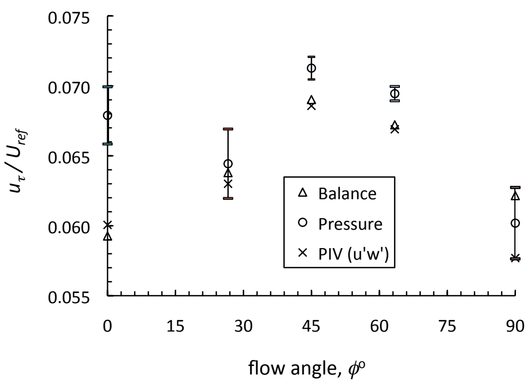

Fig.1 Variation of normalized friction velocity with wind angle for a staggered array of uniform cubes. Experiments, using pressure tapped cubes, a force balance, and particle image velocimetry.

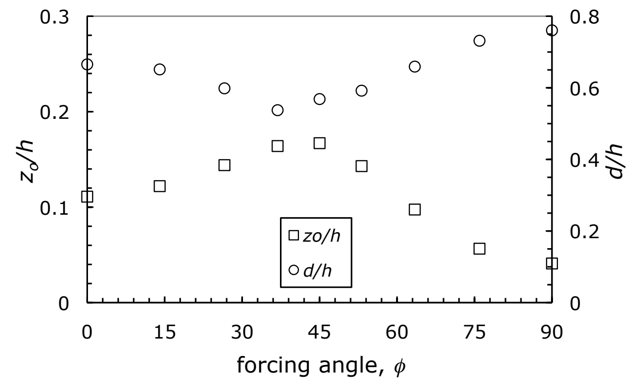

Fig.2 Variation of roughness length with wind angle, for the same array as in fig.1. Numerical results, using Large Eddy Simulation.

References

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