A THEORETICAL AND EXPERIMENTAL STUDY OF TURBULENT FLOW IN THE URBAN CANOPY

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In order to model flow and dispersion over urban and industrial sites it is often necessary to carry out simulations at a scale that is intermediate between the local and the regional, on a computational domain that might measure typically 10km, with a resolution of 100m. At this scale, it is not possible to model individual buildings explicitly, nor is it possible to represent the buildings by a simple change in surface roughness. Therefore we need to develop a representation of the surface drag exerted by the buildings that is intermediate between a simple change in roughness and a detailed representation of each building. Ideally, such a technique should be able to exploit the enormous quantities of data that are now becoming available for many urban and industrial sites, through the use of Graphical Information Systems, which often provide such detailed descriptions that it is possible to resolve individual buildings. The technique must also be compatible with the modelling assumptions used to calculate flow and dispersion.

The approach that we have adopted is to represent groups of buildings by a porous layer, with a permeability that depends on the size, orientation, spacing and topological organisation of the obstacles as well as the direction and vertical profile of the wind. The first problem in the use of such an approach is the determination of the relationship between the permeability that should be used in the model, as a function of these different parameters. The second problem concerns the way in which the porous layer should be represented in the numerical model, and this will also depend on the type of model that is used; in the work presented here, we have been working with the atmospheric dispersion code *MERCURE* developed by EDF.

The permeability of the porous layer represents the drag exerted by a group of obstacles on the flow in the boundary layer. One way of estimating this permeability is therefore to measure the drag exerted by the boundary layer flow on the obstacles, which will be equal and opposite to the drag exerted by the obstacles on the flow. We have therefore carried out a series of experiments in the atmospheric wind tunnel at the Ecole Centrale de Lyon, using groups of obstacles mounted on a large aerodynamic balance (1.8m x 1.8m) developed specially for this study. The force on a group of obstacles has been measured for different wind speeds, different obstacles sizes, different spacings and different configurations. The mean and fluctuating wind velocities within and above the obstacle groups have also been measured using Laser Doppler Anemometry.

In parallel with this work we have developed a theoretical model for flow in the porous canopy layer, by analogy with the methods used in the study of porous media. The model takes account of various geometric parameters, including the size and spacing of the obstacles, and their organisation. It has been compared with the data obtained from the measurements in the wind tunnel, and the experimental study of MacDonald (2000) in a water channel. The results are encouraging, and demonstrate clearly the role played by certain parameters such as the topological organisation of the obstacles.