LA-UR-02-1217

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Title: Fast Response Modeling of a Two Building Urban Street Canyon

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Submitted to: 4th AMS Urban Environment Conference, Norfolk, VA, May 2002

Los Alamos
NATIONAL LABORATORY

J1.4 FAST RESPONSE MODELING OF A TWO BUILDING URBAN STREET CANYON

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1. INTRODUCTION

QWIC-URB is a fast response model designed to generate high resolution, 3-dimensional wind fields around buildings. The wind fields are produced using a mass consistent diagnostic wind model based on the work of Röckle (1990, 1998) and Kaplan & Dinar (1996).

QWIC-URB has been used for producing wind fields around single buildings with various incident wind angles (Pardyjak and Brown 2001). Recently, the model has been expanded to consider two-building, 3D canyon flow. That is, two rectangular parallelepipeds of height *H*, crosswind width *W*, and length *L* separated by a distance *S*.

The purpose of this work is to continue to evaluate the Röckle (1990) model and develop improvements. In this paper, the model is compared to the twin high-rise building data set of Ohba *et al.* (1993, hereafter OSL93). Although the model qualitatively predicts the flow field fairly well for simple canyon flow, it over predicts the strength of vortex circulation and fails to reproduce the upstream rotor.

2. MODEL DESCRIPTION

An initial wind field is prescribed (u_o, v_o, w_o) based on an incident flow, u_{in}, and the various flow effects associated with building geometries and the ground. These effects are accounted for by incorporating empirical parameterizations of various flow regimes associated with flow around buildings. The final velocity field (u, v, w) is obtained by forcing the initial velocity field to be mass consistent. For simple geometries, the resulting complex 3D velocity field resembles a time-averaged experimental result.

For a street canyon with two buildings of equal dimensions, the upwind eddy of the first building, down-stream cavity and recovery zones behind the second building were specified using the same parameterizations as those used in the single building case (e.g., see Pardyjak and Brown 2001). Similar to Kaplan and Dinar (1996), the canyon flow was parameterized by two flow regimes: skimming (when $S < 1.25H + 0.15W$ for $W/H < 2$ and $S < 1.55H$ for $W/H \geq 2$) and isolated flow. In the skimming regime a simple vortex is imposed between the buildings and the horizontal velocity component perpendicular to the canyon axis is specified as:

$$\frac{U(x,y,z)}{U(H)} = \frac{d}{(0.5S)}\left(\frac{S-d}{0.5S}\right)$$

$$\frac{w(x,y,z)}{U(H)} = -\left|\frac{1}{2}\left(1-\frac{d}{0.5S}\right)\left(1-\frac{S-d}{0.5S}\right)\right|,$$

where *S* is the spacing between the buildings, *d* is the distance downwind from the backside of the upwind building, *w* is the vertical velocity component and *U(H)* is the wind velocity at the top of the upwind building.

3. RESULTS

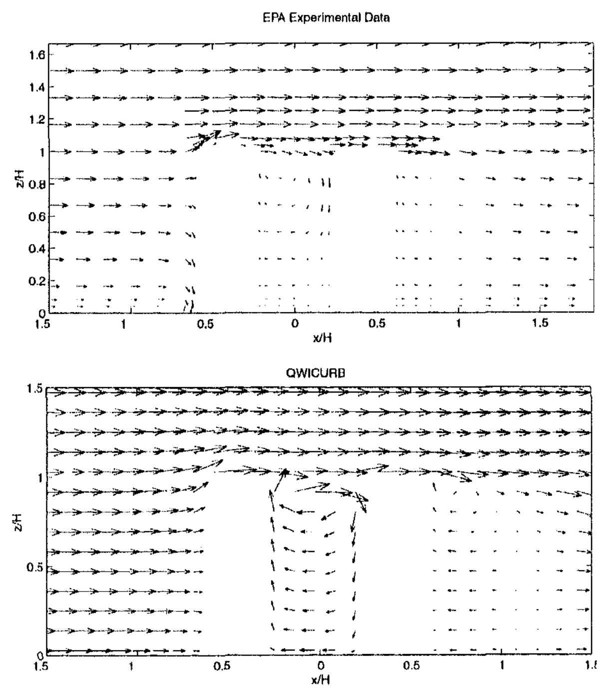

Fig. 1: Wind vectors comparison between Ohba *et al.* (1993) data and QWIC-URB along the centerline.

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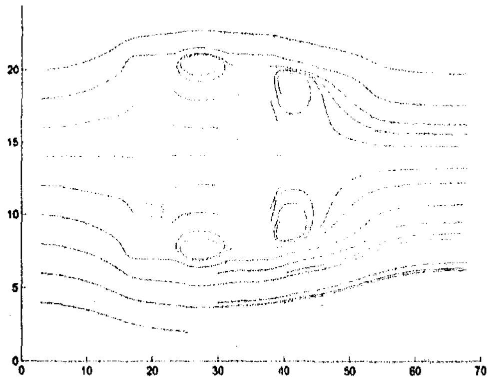

Fig. 2: Plan view of streamlines showing wall-normal vortices generated by QWIC-URB. (freestream wind is from left to right).

Velocity vectors from the two-building high-rise data set of OSL93 and QWIC-URB calculations are shown in Fig. 1. The building dimensions for the case shown are *L=W=H/3* and the spacing between buildings *S=H/2*. The canyon cavity in QWIC-URB is qualitatively similar to the OSL93 cavity, however the OSL93 cavity is weaker and not centered within the canyon (shifted slightly upwind). The reattachment length for the downwind building cavity given by the OSL93 data is ~0.4H and for QWIC-URB ~0.5H.

The QWIC-URB model shows no front eddy on the upwind building, indicating that for this high aspect ratio flow, the mass conservation procedure may overwhelm the parameterization placed upwind of the first building and the flow just goes around the building. The experimental data indicate that in fact, a small recirculation region does exist. Also, as was the case for the single building case, QWIC-URB generates a small jet at the top upwind corner of the first building, but does not produce the rooftop recirculation region.

Figure 2 and 3 are plots from a QWIC-URB calculation of two wider buildings with *L=H=W/2* and the spacing between buildings *S=1.5H*. As shown in Fig. 2, while not explicitly specified, the model generates two wall normal vortices near the edges of the canyon that may impact transport from the canyon. Fig. 3 shows particle traces for the same case supporting this idea.

4. SUMMARY

QWIC-URB was compared to the twin high-rise building data of Ohba *et al.* (1993). The results qualitatively predict the flow field well for simple canyon flow, however, significant quantitative differences were found. For larger *W/H*, the mass conservation method produces physically significant wall normal canyon vortices that may be important in the transport of pollutants out of the canyon.

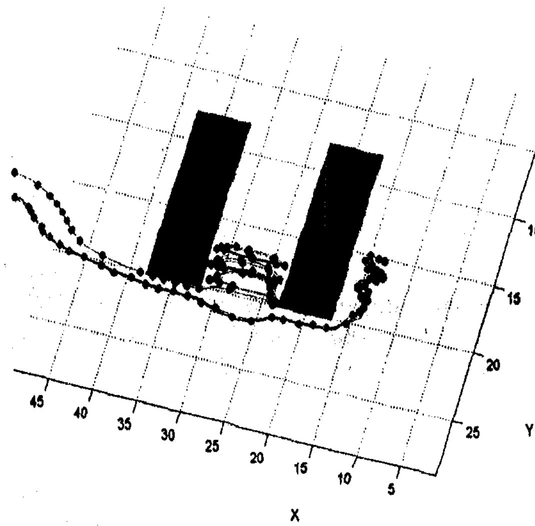

Fig. 3: Particle traces showing the upstream and canyon vortices (freestream wind is from right to left normal to the obstacles).

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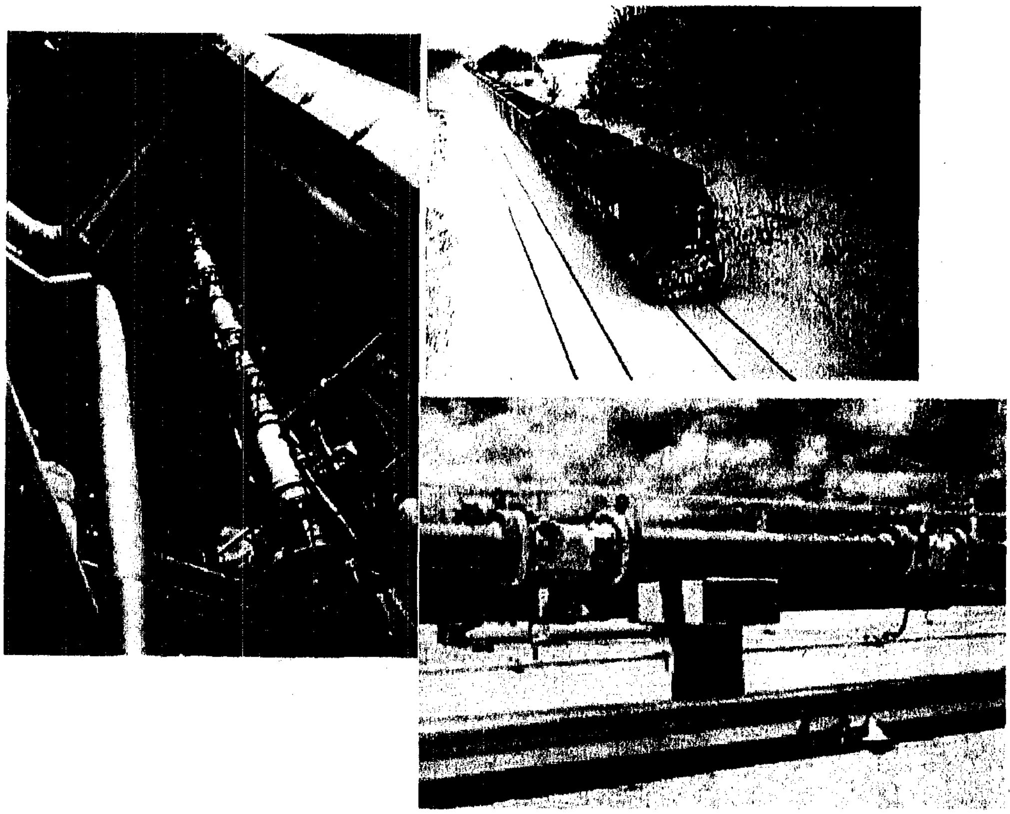

LA-UR-01-951

JANUARY 2001