Alan G. Davenport Wind Engineering Group, *The Boundary Layer Wind Tunnel Laboratory*

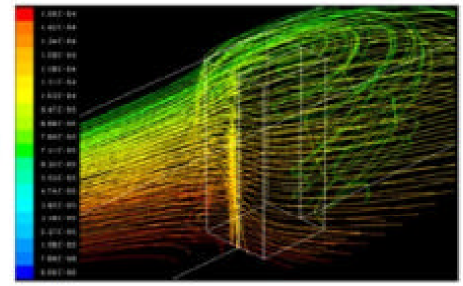
Wind-Driven Rain Studies. A C-FD-E Approach

Wind Tunnel

Summary

Wind-driven rain studies provide the main input to problems such as: precipitation protection, sealing, drainage accumulation. A Computational Fluid Dynamics (CFD) methodology is developed and used to compute trajectories and local intensity factors for generic buildings, previously tested in the wind tunnel. The methodology is further on applied in investigating real problems such as the role played by cornice in protecting the upper part of a low-rise building or the wetting and downwash on a sloped face of a high-rise building.

CFD



METHODOLOGY, Models:

- **Wind flow around buildings**: Navier-Stokes, continuity, turbulence models
- **Raindrops , size distribution:** mass fraction of droplets larger than d, $Md = \exp\left[-\left(\frac{d}{\bar{d}}\right)^n\right]$

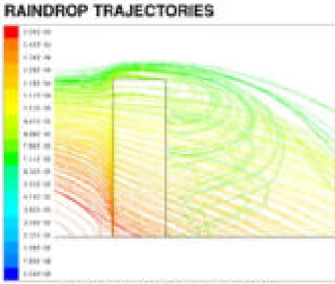
with $\bar{d} = bR_0^p$ =mean diameter, n spread parameter, and R_0 the undisturbed rainfall intensity

Trajectories (Lagrangian): $\rho_p \frac{\partial u}{\partial t} = F_D(u_i - u_p) + g(\rho_p - \rho)$ with $F_D = \frac{18\nu\rho}{d_p^2}\frac{C_D \mathrm{Re}}{24}$

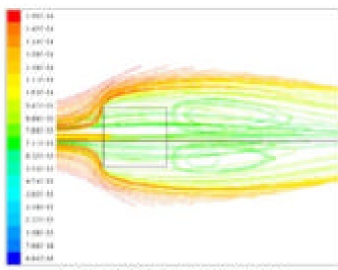
Stokes drag, u_i and u_p wind and particle velocities.

Impact: Local Intensity Factor: LIF_j = the rainfall intensity on each building zone, Ri, reported to undisturbed rainfall intensity R_0.

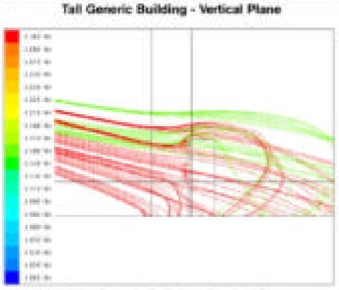
RAINDROP TRAJECTORIES



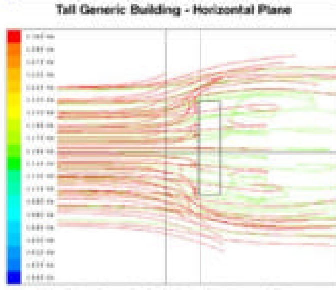
Tall Generic Building - Vertical Plane



Tall Generic Building - Horizontal Plane



Low-Rise Generic Building - Vertical Plane



Low-Rise Generic Building - Horizontal Plane

EXPERIMENTAL versus NUMERICAL RESUTLTS

Local Intensity Factors (LIF's) for the Two Generic Buildings - CFD and Experiment

CFD	EXP.	Choi (CFD)
1.6	2.7	1.2
1.2	1.7	0.8
0.8	1.2	0.7
0.3	0.7	0.5
Ro = 9 mm/hr	Ro = 10 mm/hr	Ro = 15 mm/hr

Tall Generic Building

	CFD	Avg. = 0.41
	0.43	0.5
	0.26	0.37
	0.43	0.37
	0.22	0.33
	EXP.	**Avg. = 0.46**
	0.68	0.68
	0.11	0.26
	0.13	0.41
	0.29	0.29

Low-Rise Generic Building

APPLICATION – Cornice Effect for Low-Rise Building:

Cornice effect: Fj = ratio (for every zone) between the LIF's without and with cornice:

$$Fj = \frac{(LIFj)\text{ without cornice}}{(LIFj)\text{ with cornice}}$$

If Fj > 1 cornice has positive effect

If Fj < 1 cornice has negative effect