CFD Applications in Building Design and Planning

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April 7th, 2004
Outline

- Background
  What, why, and how
- Indoor Applications
  Balcony Case
- Outdoor Applications
  Flow around building
- Conclusion
What is CFD?

• Computational Fluid Dynamics

• Divide a space into fine cells

• Predict the fluid motion under certain boundary conditions
What does CFD do?

- Airflow Distribution
- Temperature profile
- Contaminant Transport
- Thermal comfort
Why using CFD?

Existing methods to study fluid dynamics:
• Analytical or simple empirical models
  Not applicable for complex problems
• Full or reduced scale model Experiments
  Expensive, time consuming
• Numerical Methods (CFD)
  Inexpensive, fast
How does CFD work?

- Geometry input
- Boundary condition
- Preprocessing
- Calculation
- Post processing
Balcony Case
Geometry – Calculation Domain
Geometry – Interior Layout
Boundary Conditions - Wind

- Wind direction
  0 incident angle
- Wind velocity
  2.0 m/s
- Outlet
  mass conservation
Boundary Conditions – Thermal

- Adiabatic
  Wall, Floor, Ceiling
- Heat source
  Human, Computer
- Surface temperature
  Wall
Numerical Settings

- Initial guess value
- Iteration control
- Relaxation control
- Output selection
Result – Velocity (Aerial)
Result – Velocity (Interior)
Result – Flow Visualization
Result – Temperature
Outdoor Airflow
## Outdoor Comfort Concept

<table>
<thead>
<tr>
<th>Beaufort No.</th>
<th>Description</th>
<th>Wind Velocity (m/s)</th>
<th>Wind Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Light breeze</td>
<td>1.6-3.3</td>
<td>Wind felt on face</td>
</tr>
<tr>
<td>3</td>
<td>Gentle breeze</td>
<td>3.4-5.4</td>
<td>Hair disturbed</td>
</tr>
<tr>
<td>4</td>
<td>Moderate breeze</td>
<td>5.5-7.9</td>
<td>Raise dust and loose paper</td>
</tr>
<tr>
<td>5</td>
<td>Fresh breeze</td>
<td>8.0-10.7</td>
<td>Wind force felt by body</td>
</tr>
<tr>
<td>6</td>
<td>Strong breeze</td>
<td>10.8-13.8</td>
<td>Umbrellas used with difficulty</td>
</tr>
<tr>
<td>7</td>
<td>Near gale</td>
<td>13.9-17.1</td>
<td>Inconvenience felt when walking</td>
</tr>
<tr>
<td>8</td>
<td>Gale</td>
<td>17.2-20.7</td>
<td>Generally impedes progress</td>
</tr>
<tr>
<td>9</td>
<td>Strong Gale</td>
<td>20.8-24.4</td>
<td>People blown over</td>
</tr>
</tbody>
</table>
Case - Lanqiying
Calculation Domain

- Including all the buildings
- 3 times in width and length
- 5 times in height direction
Boundary Conditions - Wind Direction

- Whether data in Beijing 1960-1990
- Wind Rose
- Fall & Winter – North and Northwest
  Average velocity 3m/s, frequent 5m/s
- Spring & Summer – South and Southwest
  Average velocity 5.5m/s
Boundary conditions – Wind profile

\[ \frac{U}{U_g} = \left( \frac{Z}{Z_g} \right)^{0.28} \]

Z 10m  U  5m/s
North Wind (1.5m above the ground)
Northwest wind, 1.5m
Vertical Distribution
Conclusion

- CFD is a fast and reliable tool for building analysis.
- CFD can predict parameters such as Flow, temperature, CO2 concentration in great details.
- CFD can be widely used to guide ventilation system design and building planning.
The END

Thanks!