## Causes of Unpleasant Pedestrian Wind Conditions

Leighton Cochran[1] PhD CPEng

[1]Senior Associate, Cermak Peterka Petersen Inc., 1415 Blue Spruce Drive, Fort Collins, CO 80524, USA; PH (970) 221-3371; FAX (970) 221 3124; email: lcochran@cppwind.com

### *Introduction*

A windy environment around the base of a building, particularly near a main entrance or plaza area, will detract from the appeal of the site and perhaps discourage owners, clients and shoppers from visiting the area. Many examples exist of unsuccessful outdoor restaurants and cafes in a windy environment at the base of tall buildings (Cochran, 1979). Similarly, an outdoor pedestrian space, such as a recreational pool area (Figure 1) of a residential condominium, should be protected from strong, mean winds. Thus, there is a direct financial motivation to ameliorate the wind environment if it is going to adversely influence the appeal of a building to the owners and customers of that building. In the extreme case a site may be dangerous, particularly to the infirm. Penwarden and Wise (1975) discuss the case of two elderly women who were killed when a gust of wind at the base of a tall building blew them over. Whilst this is not a common event, potential litigation is a design parameter that should be considered.

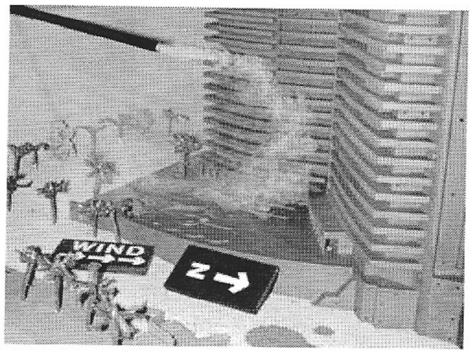


**Figure 1: Downwash circulates over the podium pool deck of a 1:300 wind-tunnel model of a beachside condominium. This circulation requires ameliorative measures like open trellises and high-canopy foliage.**

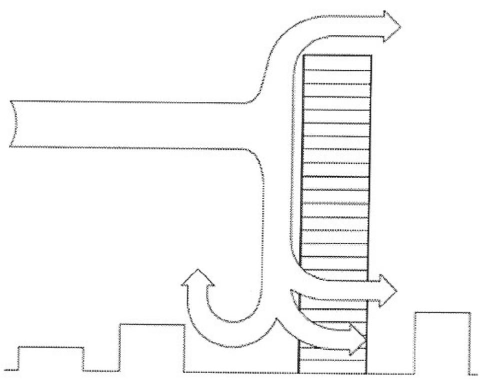

**Figure 2: Downwash to street level may generate windy conditions for pedestrians. This is particularly true for buildings much taller than the surrounding buildings.**

It is for this reason that many new-building designers evaluate their project in a boundary-layer wind tunnel with the subject building both installed and removed from the turntable. In this way, the project's impact on the local environment may also be assessed. The experience gained from studies like these will form the basis of this contribution to the Workshop. Additionally, architectural geometries that should be avoided will be presented; such as the 1960s architectural trend of having tall buildings on ground-floor columns with an open plaza underneath or having the main ground-floor entrance on a corner rather than recessed at the center of a face. The companion paper (Cochran, 2004) notes that once the flow physics are understood, the alteration of architectural massing or landscaping modifications may be used to create a pleasant pedestrian area from one that was unacceptable previously.

***Building Massing and Orientation***

It is well known that the design of a building will influence the quality of the ambient wind environment at its base. A shear curtainwall to ground level with a rectilinear floor plan (circular shapes typically do not cause flows of this type) is often a design which may aggravate street-level winds by allowing the high-elevation, faster winds to flow down the face of the structure. The mechanism is called downwash (see Figures 1 and 2). Once the wind reaches the ground it is then accelerated around the ground-level corners (see Figure 3). A large canopy may interrupt the flow as it moves down the windward face of the building. This will protect the entrances and sidewalk area by deflecting the downwash at the second-storey level (Figure 4). However, this approach *may* have the effect of transferring the breezy conditions to the other side of the street. Large canopies are a common feature near the main entrances of major office buildings. The architect may elect to use an extensive podium for the same purpose if there is sufficient land and it complies with the design mandate (Figure 5). This is a common architectural feature for many major projects in recent years, but it may be self-defeating if the architect wishes to use the podium roof for long-term pedestrian activities, such as a pool or tennis court.

Another massing issue, which may be a cause of strong ground-level winds, is an arcade or thoroughfare opening from one side of the building to the other. This effectively connects a positive-pressure region on the windward side with a negative-pressure region on the lee side. A strong flow through the opening often results as illustrated in Figure 6. A similar phenomenon occurs with a high-rise building raised up on columns, a design popular in the 1960s (Penwarden and Wise, 1975). The uninvitingly windy nature of these open areas is a contributing reason behind the rarity of this type of architectural form in modern high-rise buildings. One exception is in calm, tropical climates where the extra breeze creates a desirable feature. For example, the Hitachi Building in Singapore has used this approach to

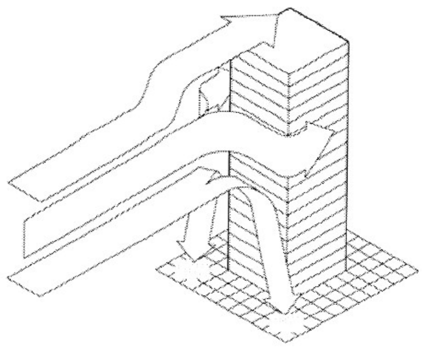

**Figure 3: Windy areas may be expected at the ground-level corners where downwash accelerates into a horizontal direction along the street.**

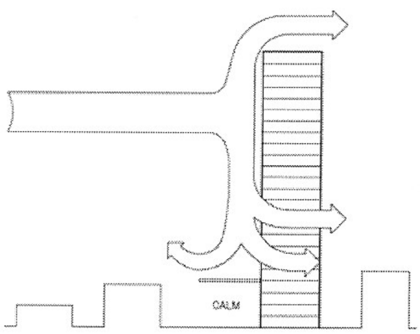


**Figure 4: A large canopy will help the subject building, but may move the high winds across the street.**

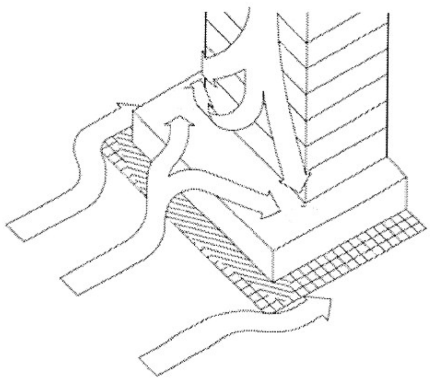

**Figure 5: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable for long-term activities.**

provide shaded, cooler areas at the ground-level entrances with great success. However, the same design in a windy city with cold winters, like Chicago, would be an unfortunate design choice.

An entrance alcove behind the building line will generally produce a calmer entrance area (Figure 7) at a mid-building location. In some cases a canopy may not be necessary with this scenario, depending on the local geometry and directional wind characteristics. The same undercut design at a building corner is usually quite unsuccessful (Figure 8). This is due to the accelerated flow mechanism described in Figure 3 and the ambient directional wind statistics - often described graphically using a wind rose. If there is a strong directional wind preference at the city in question, and the corner door is shielded from those common stronger winds, then the corner entrance may work. However, it is more common for a corner entrance to be adversely impacted by this local building geometry, along with the strong winds that more commonly occur in that city - both influencing the exposed corner entrance. The result can range from simply unpleasant conditions to a frequent inability to open or close the doors (Figure 8).

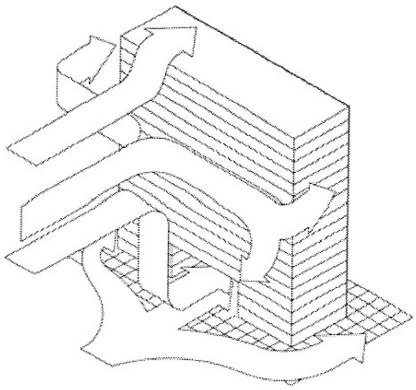

**Figure 6: An arcade or open column plaza under a building frequently generates strong pedestrian wind conditions.**

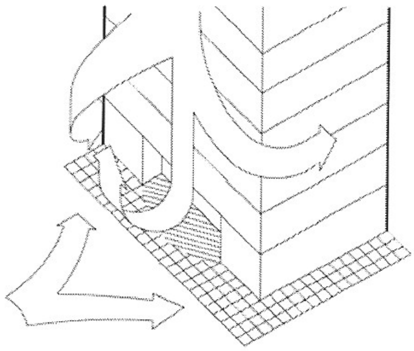

**Figure 7: A mid-building alcove entrance usually results in an inviting and calm location.**

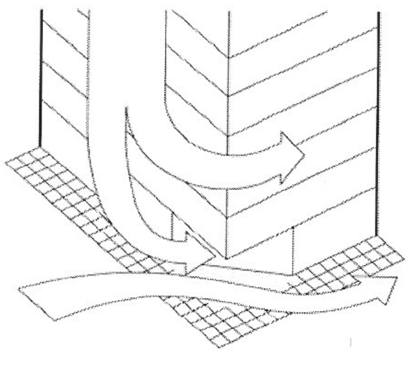

**Figure 8: Accelerated corner flow from downwash often yields an unpleasant entrance area.**

The way in which a building's vertical line is broken up may also have an impact. For example, if the floor plans have a decreasing area with height the flow down the "stepped" windward face may be greatly diminished. To a lesser extent the presence of many balconies can have a similar impact on ground-level winds, although this is far less certain and more geometry dependent. Condominium designs with many elevated balconies and terrace areas near building ends or corners often attract a windy environment to those locations (Figure 9). Mid-building balconies, on the broad face, are usually a lot calmer. Corner balconies are generally windy and so the owner is likely to be selective about when the balcony is used or endeavours to find a protected portion of the balcony that allows more frequent use, even when the wind is blowing.

The horizontal flow in Figure 9 will often occur around shorter buildings at ground level too. The lack of downwash often induces a more two-dimensional flow between the buildings, which is best ameliorated by porous screens, fences and extensive foliage (Cochran, 2004). Figure 10 shows a simplified view of horizontally accelerated flows. In reality most projects exhibit a combination of these two mechanisms, but an understanding of the flow physics allows the wind engineer to guide the architect to the most efficient, and architecturally acceptable, solution.

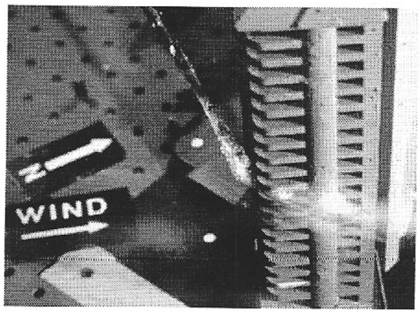


**Figure 9: Strong flow through elevated corner and end balconies may diminish their usefulness.**

### *Conclusions*

In summary, there are two principal types of flow that adversely effect the pedestrian environment: (i) downwash flows bring higher energy wind to lower elevations (usually best deflected by a podium or large canopy), and (ii) horizontally accelerated flows (often ameliorated by porous screens or plantings). These methodologies are discussed in the companion paper (Cochran, 2004). Examples of hot-film data will be used to illustrate the efficacy of these approaches during the presentation in Darwin. Lastly, the general-flow, line-diagram illustrations shown here were originally developed by Professor Jack Cermak of Colorado State University in 1980 (Rush, 1980).

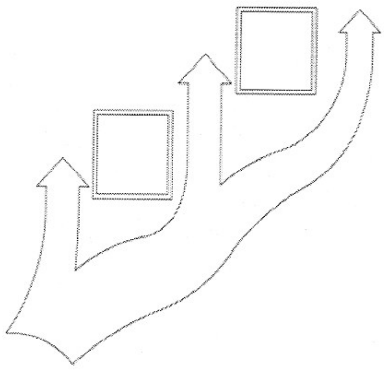

**Figure 10: Wind may be accelerated horizontally between buildings with an adverse impact on pedestrians.**

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