Solutions to Unpleasant Pedestrian Wind Conditions

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Introduction

Many factors will have an impact on the wind conditions around a building. Some of these parameters include: the ambient wind statistics, local topography (Figure 1), building massing, nearby foliage and the proximity of similarly tall structures. These all may influence the resulting winds around the base of a new building and at elevated levels on balconies and terraces. Some of these parameters fall under the control of the designers, while some do not.

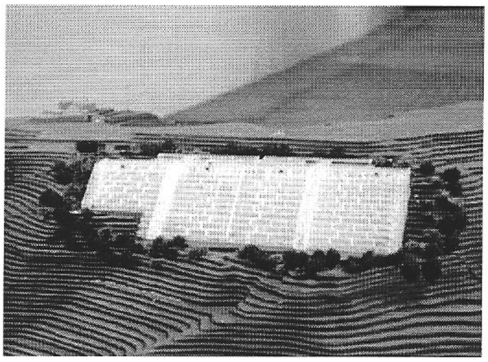


Figure 1: Filipino condominium at Lake Taal within the complex terrain of a major escarpment.

The Influence of Terrain

The presence of topography around a site will impact the ambient pedestrian conditions in much the same way as major neighbouring buildings do in the vicinity of proposed new development. Figure 2 shows the complex terrain of Victoria Peak on Hong Kong, China. Being in the shadow of substantial topography such as this is known to impact pedestrian-wind conditions and must be physically modeled in the wind tunnel to make a reliable assessment of the higher-speed winds (pedestrian comfort) and lower-speed winds (removal of pollution or viruses such as SARS) around the anthropogenic environment being assessed. In some circumstances the new building is an integral part of the complex terrain (Figure 1) and so flow over the terrain passes over the balconies of the condominium in much the same manner as the escarpment itself. Thus, the terrain at a new building site may reduce the wind speeds by shielding the new development, or it may speed up the local winds due to the presence of a hill or escarpment. In fact, both phenomena may occur on the same project, depending on the wind direction being studied.

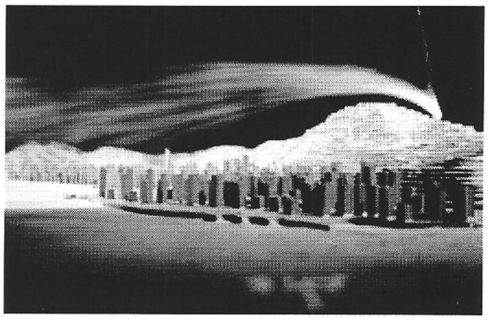


Figure 2: Gross topographic influence on pedestrian wind conditions.

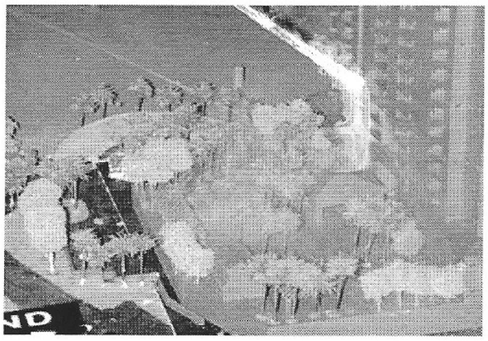


Figure 3: A porte cochere, some high-canopy foliage and a porous trellis all act to deflect the downwash off the tower.

Use of Canopies, Trellises and High Canopy Foliage

Once the flow mechanism at a problem location has been established (Cochran, 2004) for the critical wind directions the remedial solutions may be explored for effectiveness in a boundary-layer wind tunnel. At model scales ranging from about 1:200 to 1:500, locations of interest may be investigated using a variety of techniques. One of the most common is the hot-film or hot-wire anemometer shown in Figure 4. This fine wire is well suited to measuring both the mean and peak gust wind speeds at the pedestrian locations of interest due to its low thermal inertia. The hot film (more robust than a hot wire) may be fixed at the desired location for data collection, or be installed on a computer-controlled traverse for movement to sequential sites on the model (Law Flay and Barthel, 2003). Downwash off a tower may be deflected away from ground-level pedestrian areas by large canopies or podium blocks. The downwash then effectively impacts the canopy or podium roof rather than the public areas at the base of the tower. Provided that the podium roof area (or even a porte cochere upper surface in one Florida project) is not intended for long-term recreational use (e.g. swimming pool, tennis court or putting green), this massing method is typically quite successful. However, some large recreational areas may need the wind to be deflected away without blocking the sun and so a large canopy is not an option. Downwash deflected over expansive decks like these may often be improved by installing elevated trellis structures (Figure 5) or a dense network of trees to create a high, bushy canopy (Figure 3) over the long-term recreational areas. Melbourne and Joubert (1971) discuss the impact of mixing tall and short buildings to reduce strong winds at ground level. Thus, various architecturally acceptable ideas may be explored in the wind tunnel prior to any major financial commitment on the project site.

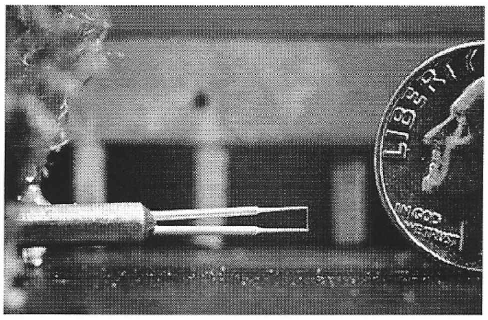


Figure 4: The hot-film anemometer uses variations in electrical resistance, induced by cooling due to airflow, to measure mean and peak wind speeds in the boundary-layer wind tunnel.

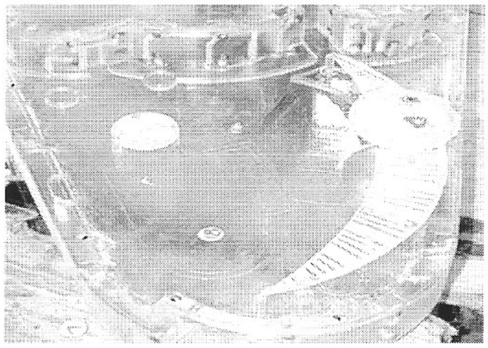


Figure 5: A large-area porous trellis used to diminish the downwash-induced winds over a podium pool deck at a coastal Florida condominium.

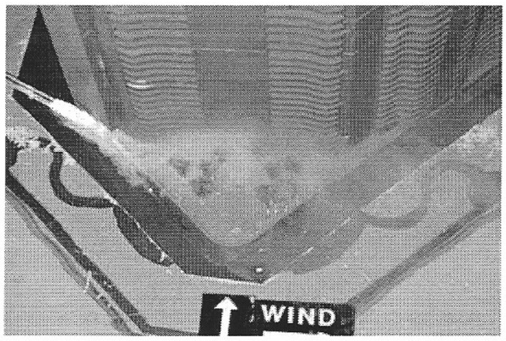


Figure 6: Accelerated flow around a tower corner washes over a pool deck. Porous screens and foliage are needed.

Use of Landscaping Foliage and Porous or Solid Screens

Horizontally accelerated flows (Figure 6) around the base of an exposed tall tower may cause an unpleasant, windy, ground-level pedestrian environment, which could also be locally aggravated by ground topography. By inspection of the available wind data, the designer may find a dominant wind direction that can be used to align the buildings on the site so as to minimize these accelerated flows in highly trafficked pedestrian areas. In major entrance areas it is rarely an option to use extensive planting or porous screens to reduce the speed of the flow through the area (Figure 7). However, these landscaping techniques are the preferred methodology to ameliorate winds that are principally horizontal (i.e. not the vertical downwash flow discussed previously). Extensive planting was used to improve conditions on the pool decks in Figures 6 and 8. The accelerated flow around the corner of the tower in Figure 6 was retarded using foliage and tall porous parapet screens on the podium perimeter. In Figure 8 massive planting and the use of porous screens calmed this hotel recreational area on the beach in Aruba from the very dominant easterly breezes.

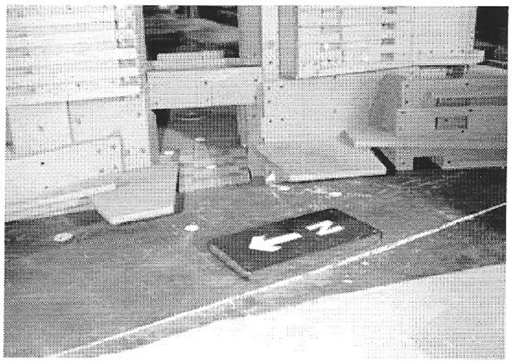


Figure 7: Horizontally accelerated flow between two tall towers may be minimized by judicious orientation away from dominant winds.

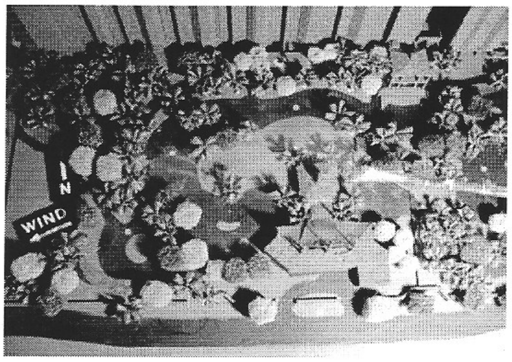


Figure 8: A detailed multi-phase study of a beachside hotel complex (pools, putting green, restaurant/bar etc.) with porous screens and extensive foliage.

Horizontally accelerated flows that create a windy environment are best dealt with by using porous screens or substantial landscaping. Large hedges, bushes or other porous media serve to retard the flow and absorb the energy produced by the wind. A solidity ratio (i.e. proportion of solid area to total area) of about 60% has been shown to be most effective in reducing the flow's momentum (Rouse, 1950). These physical changes to the pedestrian areas are most easily evaluated by a model study in a boundary-layer wind tunnel. Figure 9 shows a tennis court that was part of a Taiwanese beachside condominium development. By using trees to protect from key wind directions and a 3-m high porous perimeter fence, the conditions on the court were substantially improved. A comparative study showing the impact on the site with and without the ameliorative additions is a useful method of defining their effectiveness, and it also allows the architect to define the extent and usefulness of the pedestrian space. When these

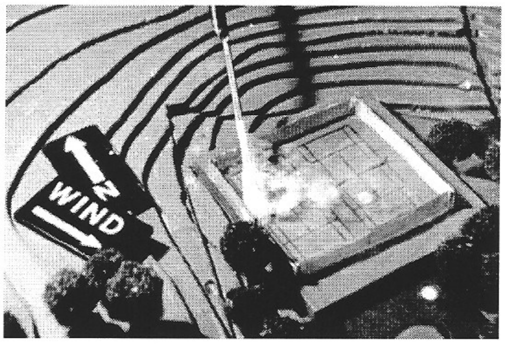
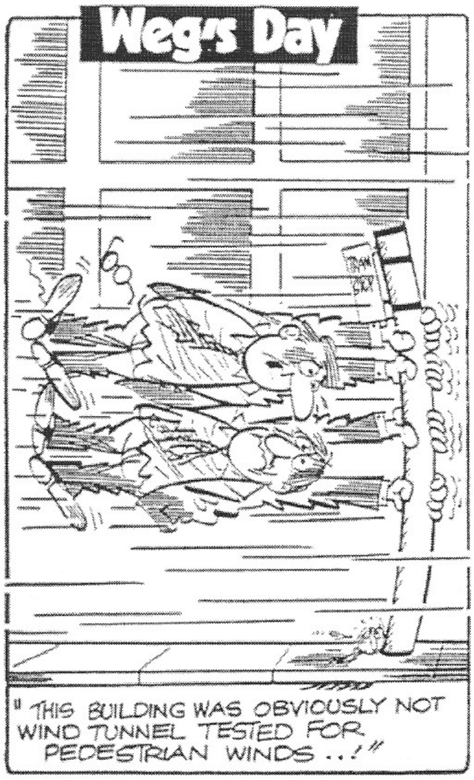


Figure 9: Foliage and porous fence were used to substantially reduce the wind speeds on these tennis courts.

studies are done as part of the design process, the architect can be more assured of the success of open space, pool areas, balconies, terraces and entrances around a new project.



Conclusions

In summary, the wind comfort and safety of pedestrian areas around a new development may be assessed by a properly conducted wind-tunnel study, combined with direct interaction with the architect. Physical modeling of the wind flow used in conjunction with the statistical description of the ambient site winds, yields a powerful predictor of how a new project will be judged by the public, from the perspective of wind comfort, before construction commences. The knowledge gained from previous studies also provides useful massing guidance to the architect in the design phase and while exploring acceptable design options in the wind tunnel.

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