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WIND IMPACT IN ARCHITECTURAL ENGINEERING - SHAPING OF BUILDINGS

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The Paper is not intended to dictate how buildings should be designed. Rather, it outlines in non-scientific terms the basics of wind effects caused by buildings and shows how particular relationships can cause or alleviate problems. To avoid or mitigate the adverse effects of wind, specific rules apply as conditions on permitted building development.

Introduction. Building form and detailing can greatly affect wind-flow patterns and speeds. With an appreciation of how winds flow around buildings, designers can avoid creating high wind speeds at ground level. This is an especially important consideration for buildings proposed for exposed sites, and near significant sites such as parks.

The removal of a building from, or its introduction to, the central area may have no effect upon the wind environment, or it may reduce or increase wind conditions. A crucial factor is the building's relationship to adjacent buildings. In a complex situation such as the central city area, adequate wind reports prepared by an independent consultant are invaluable, whilst wind tunnel tests are frequently essential prerequisites to satisfactory developments.

1. Analysis

1.1 Safety and Comfort Aspects

Tall buildings induce changes in local ground winds. The size of these changes varies from site to site. When these wind changes happen at pedestrian level, it can make activities such as sitting, strolling, shopping, or going into a building difficult and even dangerous. In various countries it has been reported that strong pedestrian-level winds have sometimes affected the financial and operational success of new buildings.

- **Safety -** No matter how windy the City may be, ultimately pedestrian safety must be a major determinant of building design. The criteria for judging the acceptability of proposed development schemes should be the likelihood of danger to pedestrians - conditions at street level should not be worsened by a new building. It may be that a different building form could provide a higher degree of comfort.
- **Comfort -** Comfort may be considered from two aspects, wind speeds and discomfort levels.
- **Wind Speed -** It is not the mean wind speed, but rather the peak gust wind speeds and associated changes in speed which people feel most. For

some time, the concept of using peak annual three-second gusts to classify the wind environment of a site with regard to people's comfort has been used.

- **Comparative Discomfort -** Whether people are comfortable on windy days depends upon several factors, including:

  - wind speed - notably peak wind gusts o the climate and the season
  - the temperature, precipitation sunlight, shade and humidity
  - what people are doing
  - what people are wearing
  - the age and psychological state of the individual.
  -

The Paper compares a person's comfort in the vicinity of a site with no buildings, to the same person's comfort in the same area with a building in place. From this comparison a percentage increase in wind speed around the building can be derived. Throughout this guide the percentage increase in wind speed is referred to as a percentage increase in discomfort.

1.2. The Basics of Interaction Between Buildings and Wind

Buildings form obstacles to wind flows, causing a positive pressure zone to be formed on the windward face. At the same time, a negative pressure (which forms a suction) zone is created at the sides of the building. Pedestrian-level winds result from a complex reaction between the wind and the building(s), involving the building's shape, size and relationship with other buildings.

One building placed to windward of another can act as a wind shield, protecting the second building. A tower block rising out of a podium, a building with substantial verandahs around it just above pedestrian height, a building which has vents through it in non-pedestrian areas to channel wind, or a building which is circular or octagonal in shape present fewer undesirable wind effects.

The developer is often in a dilemma, undecided whether to:

- undertake a full wind tunnel test before preparing working drawings, and risk having the wind tunnel report invalidated by subsequent design changes; or
- undertake the full wind tunnel test after the preparation of working drawings, and risk the report necessitating major changes to the working drawings.

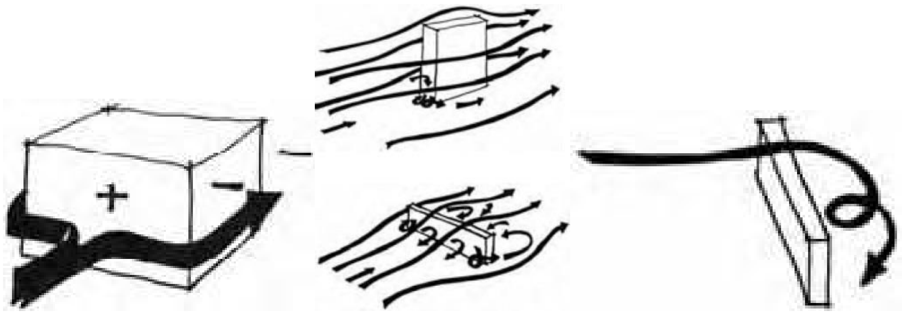

Figure1. Building – Wind Interaction

2. Wind impact on buildings

The following paragraphs summarize the likely effects of isolated buildings of simple basic form on the ground-level wind environment in their vicinity.

- **Rectangular Towers and Slab Blocks -** Because the natural wind speed increases with height, the top of a tower is exposed to wind speeds and pressures that are higher than at its base. The higher pressures at the top of a rectangular building force the air to flow down its windward face, so increasing wind speeds at pedestrian level.
- **Downwash -** The taller the building, the greater the pressure difference driving the wind. This phenomenon is known as downwash. A simple rectangular building will have a zone of increased wind speed at the base of its windward face, due to downwash. Wind flows are induced downward to street level.
- **Corner Effect -** The air concentrated at the base of the windward face of a building naturally flows rapidly from there around the windward corners of the building towards its relatively more sheltered sides and rear. The transition zone between high- and low-speed wind flows at these corners is small. Pedestrians crossing this zone encounter, unexpectedly and hence in a potentially dangerous way, sudden changes in wind speed. The greatest wind speeds are generated within a distance equal to the width of the building face.
- **Wake Effect -** Increases in wind velocities and turbulence add to the discomfort felt downwind from buildings. Much of the discomfort occurs as a result of the corner effect but it persists for a long way behind the building and can spread out, as indicated in the diagrams. Discomfort levels are worsened by increases in building height.
- **Cumulative Effect -** This cumulative increase in wind speed may be substantially reduced if existing or subsequent constructions nearby are of sufficient height to give a localised stepping-down effect. This may occur where the difference in height between the obtruding building and windward adjacent buildings is less than one-third the height of the dominant building.

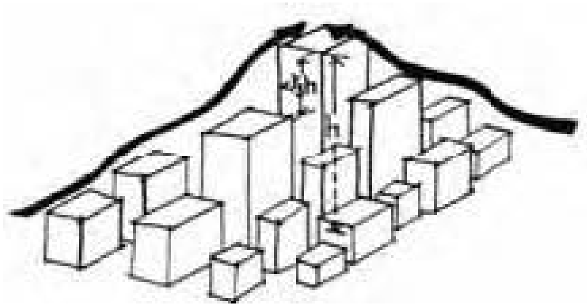

Figure 2. Cumulative Effect

• **Low Bar Buildings ("Row" Effect) -** Low, "bar"-shaped buildings which present wide unshielded faces exposed to any prevailing winds cause the wind to literally trip over these bars. When a building or group of buildings is narrow, less than 10 storeys high, and its length is approximately eight or more times its height, this causes a 40 percent increase in discomfort. One way to reduce, or even cancel, the row effect is to add one or several wings to the main block, thus localising the pedestrian wind level disturbances.

3. Remedial Treatment for Existing Situations

The modification of "final" drawings or subsequent alterations to existing buildings may sometimes be necessary to improve the local environment for the building's users and the general public. Remedial treatment is never a reasonable substitute for proper consideration of wind effects at the design stage of a project.

• **Vegetation** - The growth of trees in the area adjacent to the buildings can be prevented or distorted by the wind. However, resistant vegetation can act as a porous fence and lend a measure of protection, whereas a solid shield such as a wall or fence could encourage further pressure variations.

• **Structures** - Where buildings prove to be windy after construction, various remedial works may substantially reduce the wind effects. Two approaches may be taken: people can be protected by shields, or redirected through safer areas, for example by establishing gardens and architectural features within the danger zones.

• **Verandahs** - A substantial verandah may prevent high wind speeds descending to ground level. Care must be taken not to transfer the discomfort to another pedestrian area.

• **Enclosed Walkways** - The verandah can be extended by the addition of a side wall.

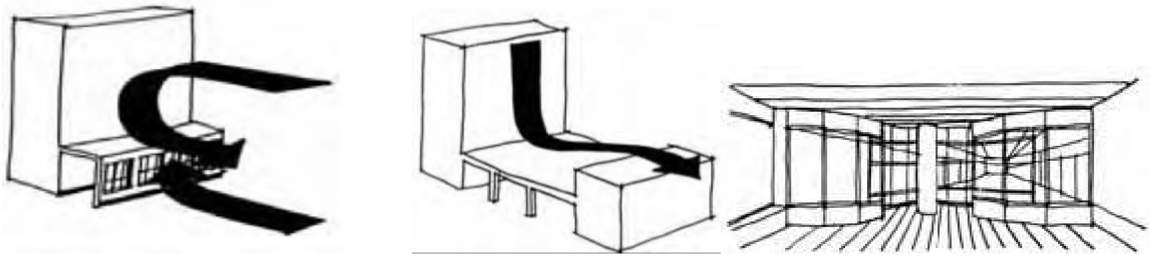

Figure 3. Enclosed Walkways, Roofing over the open spaces, Pedestrian Corridors and Foyers

- **Roofing Over the Open Spaces** - High pedestrian-usage areas such as shopping precincts can be roofed over.
- **Pedestrian Corridors and Foyers** - Although enclosing the walkways improves the situation, there may be significant discomfort from winds blowing the entire length of the enclosed walkways. These may be reduced by putting up screens, or eradicated by building doors at the end of the walkways.

Conclusion. The analysis gives an indication of the wind effects which may be avoided - or markedly reduced -if wind design is an important consideration during the initial stages of building design. The Paper is not intended to offer a set of answers; the subject is complex, and complicated wind patterns are experienced in the Wellington central area. Wind tunnel tests should be an early feature of the design process.

Acknowledgement

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УЧЁТ ВЛИЯНИЯ ВЕТРА ПРИ АРХИТЕКТУРНОМ ПРОЕКТИРОВАНИИ И ФОРМООБРАЗОВАНИИ ЗДАНИЙ

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В статье нет требований к проектированию зданий. Скорее, описываются в ненаучных терминах основы ветрового эффекта, вызванные зданиями и показывает, как конкретные связи могут вызывать или упрощать проблемы. Чтобы избежать или смягчить неблагоприятные последствия ветра, специальные правила применяются как условия, влияющие на развитие строительной отрасли.

ОБЛІК ВПЛИВУ ВІТРУ ПРИ АРХІТЕКТУРНОМУ ПРОЕКТУВАННІ І ФОРМОУТВОРЕННІ БУДІВЕЛЬ

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У статті немає вимог до проектування будівель. Швидше, описуються в ненаукових термінах основи вітрового ефекту, викликані будівлями і показуются, як конкретні зв'язки можуть викликати або полегшувати проблеми. Щоб уникнути або пом'якшити несприятливі наслідки вітру, спеціальні правила застосовуються як умови, що впливають на розвиток будівельної галузі.