Optimising ventilation and solar access

Author:
King, Steve Earnest

Publication details:
ASSESSING SEPP 65 APPLICATIONS - ESSENTIAL GUIDE FOR THE UNINITIATED

Event details:
NEERG Seminars ASSESSING SEPP 65 APPLICATIONS - ESSENTIAL GUIDE FOR THE UNINITIATED
Sydney, Australia

Publication Date:
2003

DOI:
https://doi.org/10.26190/unsworks/603

ASSESSING SEPP 65 APPLICATIONS

ESSENTIAL GUIDE FOR THE UNINITIATED

SYDNEY MASONIC CENTRE, THURSDAY 19 JUNE 2003

Optimising ventilation and solar access

Steve King

Associate Director

SOLARCH, UNSW

Introduction

Aspects of residential apartment amenity have acquired a new importance due to the influence of State Environmental Planning Policy 65 - Design of Residential Flat Buildings. SEPP65 highlights problems of assessing appropriate projected building performance to achieve compliance, both for the designer and for the approving authority.

This paper draws attention to the considerable expertise now required for such assessment. In particular, it raises the problem that failure to achieve prescribed quantitative measures often does not mean that proposed designs will fail to comply with the Policy's more complex performance criteria. The issues relate to all aspects of environmental control, notably solar access and natural ventilation — but for the sake of brevity, the discussion focuses only on the latter.

Considerable confusion exists with regard to the ventilation of apartments. Whilst SEPP 65, Principle 7 - Amenity - refers to "natural ventilation", supporting documents specify or describe "cross ventilation". The paper explores concepts of ventilation, describes the necessary conditions for natural ventilation to be effective, and considers the need for, and advantage of, cross ventilation.

Basic concepts of ventilation

Air change

At its most basic, ventilation is required to exhaust air from an interior, and replace it with 'fresh' air. Historically such air change served to remove pollutants such as combustion products and water vapour, generated by cooking and heating. Since the 19th-century, minimum ventilation rates have been invoked in various building codes and standards, usually by way of prescriptions for required openings. However, the most important role of ventilation in warmer climates is to remove accumulated heat gains during overheated periods. In all of these cases, ventilation is intended to achieve *predicted rates of volumetric air change.*

Impact on people - thermal comfort

Also important in warmer climates is the role of ventilation in directly improving the perception of thermal comfort by occupants of a space. This is achieved when, by passing over the skin, moving air aids the evaporation of perspiration. As long as there is a bit of air movement, most people will tolerate somewhat higher temperatures before they complain of discomfort. In this context, ventilation is intended to achieve *useful air velocities directed over the occupant*.

There is a practical limit on the air velocity useful for comfort ventilation. At 1m/s air speed, hair and papers begin to move. By 1.4m/s (or 5km/h) conditions are noticeably draughty, and considered a nuisance by most. Worse, planning and detailing for enhanced summer ventilation — especially the over-use of louvred windows — can have undesirable consequences in winter: increasing heat loss by cold drafts.

How is ventilation achieved?

Momentum effects

Although air has relatively little mass for a given volume, individual molecules of moving air do have appreciable momentum. Thus, any wind affecting an opening will assure that the air will move a certain minimum distance into the interior, even where no separate outlet opening is available. This is the most fundamental basis of so-called single-sided natural ventilation. By itself, it is of limited effectiveness, but hardly negligible when appreciable breezes are available.

Pressure differences

The dominant motive force that drives air movement is *relative difference in atmospheric pressure*. Air will move from a place with a relatively elevated pressure to one of lower pressure. This is true at all scales. A good way of grasping this fundamental concept is to envisage that wind does not blow, rather it 'sucks'.

Natural ventilation is therefore most reliable when any space has at least two openings, one on a facade of the building that is experiencing a zone of relatively elevated pressure and another on one experiencing a relatively depressed pressure. Figure 1 shows simplified airflows around a building, and Figure 2 shows simplified pressure distributions on a typical tall building in plan. They make clear that under most circumstances, the required pressure differences for locating effective inlet and outlet openings may be found on either adjacent or opposite faces of the building. This is the basis on which so-called 'cross ventilation' is usually premised.

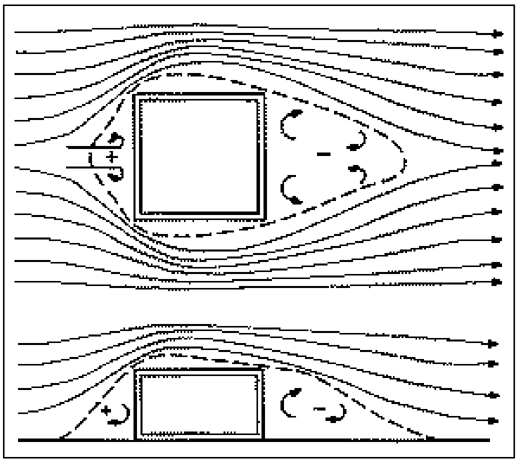


Figure 1: Airflow around buildings

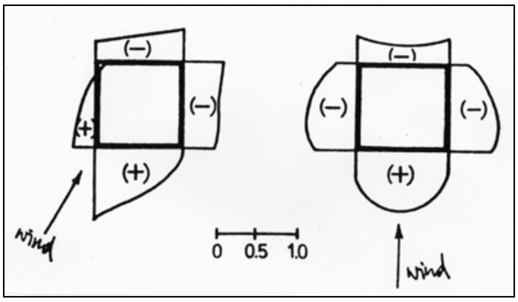


Figure 2: Simplified pressure distributions

What such simplified diagrams do not make equally clear is that there are many more detailed features of most building configurations, which also set up smaller, and more complex conditions of local pressure differences. These smaller pressure differences may nevertheless be useful in achieving some air movement through interiors.

Convection - stack effect

Another way that relatively smaller pressure gradients may be achieved is by exploiting the difference in density between cooler and warmer air. This situation occurs typically in taller interiors, where warm air rises towards the top of the containing space and is allowed to escape, while another opening near the bottom of the space allows cooler air to enter. The effectiveness of such stack effect ventilation is directly proportional to the height between the inlet and outlet openings, and the difference between the exhaust and inlet air temperatures.

Stack effect ventilation is driven by relatively small pressure differences. Therefore stack effect ventilation of normal residential interiors is likely to be completely swamped by even gentle breezes. This is especially true in coastal climates such as Sydney, where absolute calm is almost unknown.

Windows / openings

Natural ventilation is obtained and enhanced by suitable location, sizing and detailed design of openings, typically windows. The first and most important consideration is the location of inlet and outlet openings in relation to predicted pressure differences resulting from suitable prevailing breezes.

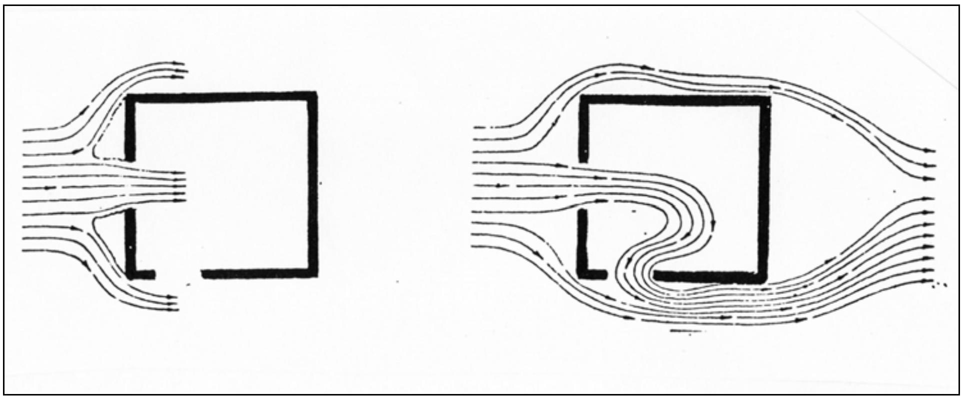


Figure 3: The role of inlet and outlet

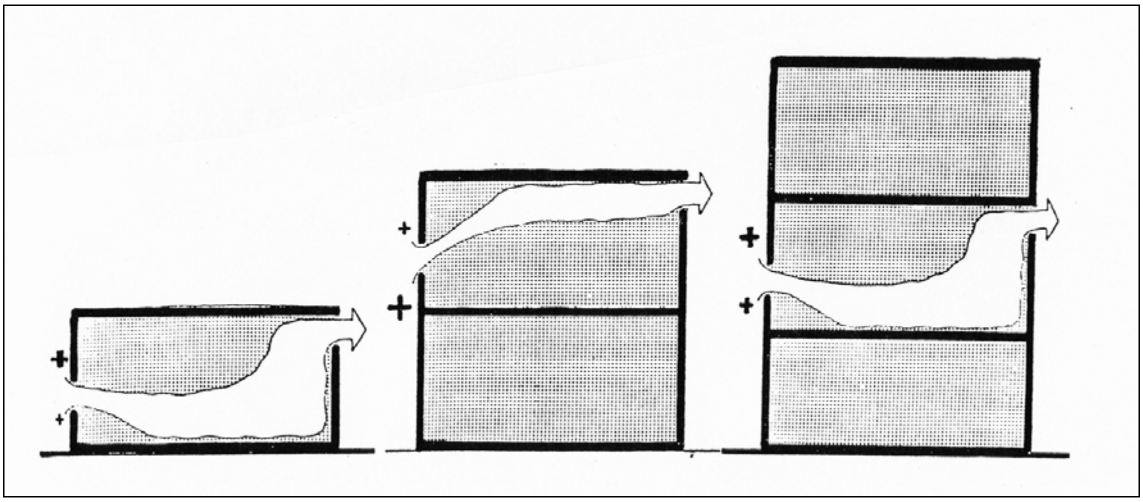


Figure 4: Effect of inlet position on ventilation pattern in the room

But little understood by most designers is that the location of the inlet opening in relation to the overall pressure distribution on the windward *facade* of a building, makes the most significant difference to air movement patterns within the interior. In comparison, the location of the outlet opening can be relatively inconsequential. Figure 3 and Figure 4 illustrate the simplest of these effects. Note how the identical window placement in relationship to the *interior* of the room can produce dramatically different ventilation patterns on different floors.

Also poorly understood is that if air movement for *comfort ventilation* is the primary issue, enhanced air velocities are obtained with *smaller*, well placed inlet openings and much *larger outlet* openings. Of course, the ventilation inlet opening may itself be a small part of a much larger view panel. Figure 5 compares typical internal air velocities (expressed as a percentage of the prevailing wind speed) as the outlet opening increases in relation to the inlet opening.

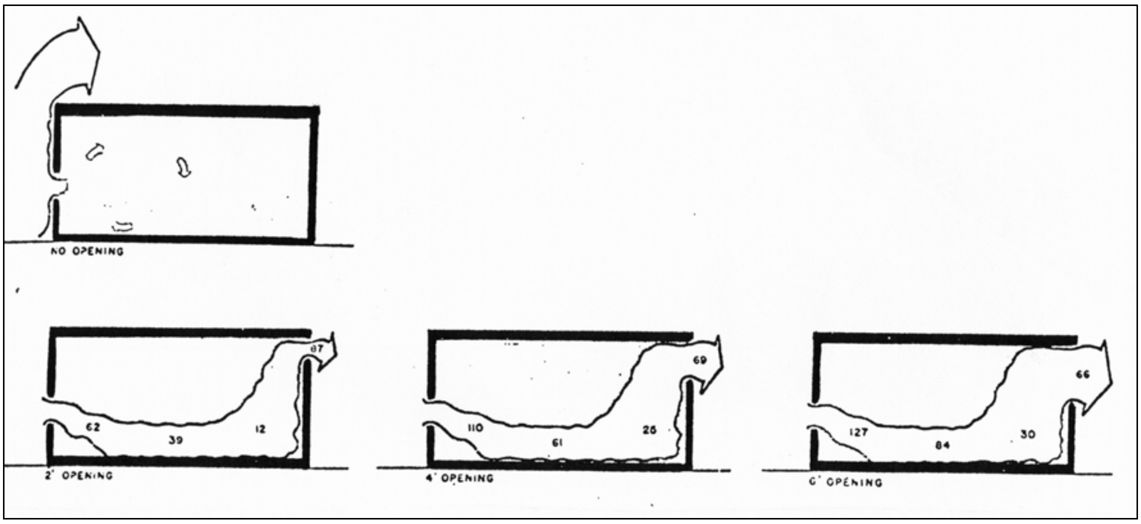


Figure 5: Relative air velocities due to inlet/outlet proportions

Capturing wind/breezes

Various factors, especially landscape design, can make significant differences to the availability of breezes for summer cooling. The most important, of course, is an appreciation of the distribution of regional prevailing winds, keeping in mind which of them are reliable sources of cooling, and at what time of day they typically occur. In Sydney we are fortunate to enjoy a fairly clear differentiation between the dominant afternoon on-shore sea breezes, and the westerly winds that are more typically a nuisance in both summer and in winter. The primary design response to the use of natural ventilation for summer cooling is therefore sensitive orientation of buildings.

However, regional wind patterns can be dramatically modified by local conditions. Channelling, downwash, wind shadow and other effects can change both the direction and velocities of available breezes within more complex developments. Some of the resulting conditions, including unfavourable orientation, may sometimes be modified by suitable landscape and building detail. The underlying principle of all such possible modifications of natural ventilation potential is systematic design to achieve suitable relative pressure differences between inlet and outlet openings.

Mechanical assistance

Mechanical assistance has a definite role to play in ensuring adequate ventilation. Under many circumstances in multi-dwelling design reliable exhaust ventilation is more effectively provided by mechanical means, than by difficult distortions of the overall building form. The energy requirements of exhaust fans, to meet mandated air exchange for domestic occupation, are relatively humble and may be easily justified.

More interesting is the issue of control over air movement for enhanced thermal comfort. It should now be clearly understood that air movement and volumetric air exchange can be treated as independent variables in design. In a climate like Sydney, in many apartments for much of a summer day, the temperature inside is likely to be a lot cooler than the air outside. *To open windows at those times actually serves to heat up the interior more quickly.* In such circumstances, ceiling fans are a much more effective option for reducing the requirement for air conditioning, than any attempt to achieve similar air movement effects by completely passive means. It is not an accident that ceiling fans are so common in warm humid climates.

Cross ventilation

What is meant by cross-ventilation?

'Cross-ventilation' can now be understood to describe the condition where a dwelling has operable openings to two or more distinctly different orientations, thus making likely that in any conditions of breeze, relative pressure differentials will assure some air movement through connected spaces in the dwelling.

Strictly speaking, true cross ventilation implies not only the placement of inlet and outlet openings on the opposite facades of the building. It also requires attention to the paths that air movement can take through the building interior. In order to be fully effective, and especially to maintain useful velocities for thermal comfort, the air path has to be relatively unobstructed. Design in the tropics, where such comfort ventilation is critical, is characterised by buildings with single loaded planning arrangements. The placement of interior partitions, and even furniture, is critical in maintaining relatively straight air paths in order to minimise the loss of momentum in the air stream.

Clearly, tortuous air paths through deep apartment plans, and negotiating several doors or other openings, are unlikely to deliver the desired cross ventilation outcomes.

Corners

In some respects, providing openings in adjacent facades is a special condition of cross ventilation. As we saw in Figure 2, adjacent facades may or may not generate the same reliable pressure differentials between openings, as two opposing facades with favourable wind directions. In addition, such corner conditions can actually be the cause of unfavourable internal ventilation patterns. Nevertheless, in most practical circumstances corner locations may be assumed to provide for significantly enhanced air exchange and air movement, in comparison to single sided dwellings. Sometimes, they may actually be preferable to plans that fully penetrate the building, if only because the inlet and outlet openings are more often within a single open space.

What SEPP65 says

SEPP 65

This policy aims to improve the general design quality of residential flat buildings. Within SEPP65 itself there are few quantitative or qualitative standards to regulate technical performance. Indeed, reference to ventilation as a major determinant of thermal comfort and likely energy use for heating and cooling, may only be found under Principle 7 – Amenity, which refers only to a generalized requirement for natural ventilation.

However, amongst its objectives, SEPP65 lists:

- to maximise amenity, safety and security for the benefit of its occupants and the wider community, and
- to minimise the consumption of energy from non-renewable resources, to conserve the environment and to reduce greenhouse gas emissions.

It would therefore be reasonable to assume that specific performance measures for buildings designed in compliance with SEPP65 would be scrutinized in light of these objectives.

Residential Flat Design Code

The introduction to this document clearly states:

> "The Residential Flat Design Code sets broad parameters within which good design of residential flat buildings can occur by illustrating the use of development controls and consistent guidelines. It will be an important resource for council planners responsible for creating new plans relating to residential flats and for assessing residential flat development under SEPP 65. With the SEPP, it provides the 'how to' of designing better built outcomes."

In support of this objective, the Code states explicit qualitative and quantitative standards applying to most of the technical performance factors addressed by SEPP65. The Code devotes a discrete section to natural ventilation, summed up in the following *Rules of Thumb*:

- Building depths, which support natural ventilation typically range from 10 to 18 metres.
- Sixty percent (60%) of residential units should be naturally cross ventilated.
- Twenty five percent (25%) of kitchens within a development should have access to natural ventilation.

- Developments, which seek to vary from the minimum standards, must demonstrate how natural ventilation can be satisfactorily achieved, particularly in relation to habitable rooms.
  (Building Amenity .Natural Ventilation p.87)

But any assessment will rely only on these rules alone at its peril. The explanatory text includes objectives which clearly delineate the context of fresh air ventilation, thermal comfort and minimising energy use. Comprehensive *Better Design Practice* guidelines rehearse all of the variables of building design that may contribute to achieving good natural ventilation, from landscape strategy to opening detail, albeit with a strong bias towards planning for cross ventilation.

Pattern book

The Residential Design Pattern Book is a collection of Case Studies supported by a set of principles. It predates the more prescriptive Flat Design Code, and sets out to illustrate the application of the principles of SEPP65 by example. Under the *Building Principles: Environmental Performance*, it loosely references natural ventilation, and strongly favours cross ventilation as the preferred condition.

As a consequence, the majority of the case studies, and all of the Building Types illustrated in the Pattern Book feature apartments which fully penetrate shallow blocks, and enjoy full dual aspect. There is no comparable discussion of the consequences of site constraints and other considerations, which may not allow this general approach to be followed.

Discussion

Amongst other objectives, the general intent of SEPP65 and its supporting documents is to encourage the design of apartments to avoid air conditioning, and to assure the best possible amenity by exploiting climate responsive design. Planning layouts that allow for cross ventilation definitely contribute to this objective.

However, the problem quickly becoming manifest is that both designers and planning officers are applying a rote interpretation of what constitutes a cross ventilated apartment — simply looking for the openings in two different facades. Little if any attention is being paid to whether good natural ventilation will actually be realized, such as in severely elongated ‘cross-over units’, where air paths are tortuous, and likely to be defeated by closed doors to bedrooms. Worse, the often acceptable ventilation performance of single sided units is being completely ignored.

Cross ventilation is certainly desirable in climates with little technical calm, like coastal Sydney. However, this does not mean that a more general assessment of the likely adequacy of natural ventilation cannot be made in other situations, such as where there is a predominance of single aspect dwellings.

Prior to the common availability of refrigerative air conditioning and mechanical exhaust ventilation, accepted design rules for adequate natural light and ventilation were commonly expressed in terms limiting the ‘depth’ of single sided open plan space to approximately 8m from the glazing line. This was premised on long experience of a balance between achievable air change rates, and the overall benefit of enhanced air velocities in temperate climates. Such former guidelines are echoed in the Residential Flat Design Code *Rules of Thumb* for Apartment Layout.

Contemporary trends in apartments are also increasing the likelihood of attributes that further enhance such ventilation performance. Chief amongst these is the prevalence of generously dimensioned verandahs, conceived as outdoor rooms, a trend encouraged by the Residential Flat Design Code itself. By creating significant recesses and protrusions in the façade, and often by creating local corner conditions, such terraces give rise to appreciable local pressure gradients and improvements in the ventilation of adjacent rooms.

The provision of even modest façade reveals, such as privacy screens, can have reliable effects in assuring usable ventilation patterns for some single sided apartments.

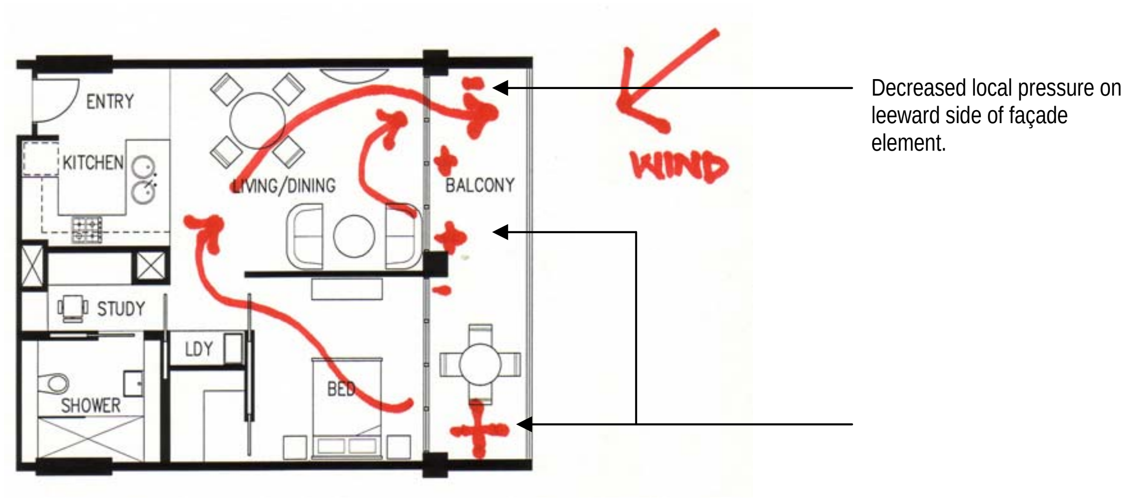


Figure 6: Variations in façade pressure distribution and resulting ventilation patterns
The illustration is of a south facing one bedroom unit on an upper floor, subject to southerly summer winds relatively common in Sydney.

For apartments on the upper floors of medium and high rise developments in Sydney, enhanced air velocities are hardly an issue. More pressing by far is to achieve construction that is sufficiently air-tight to make life tolerable in the often unacceptably windy conditions experienced at these higher levels.

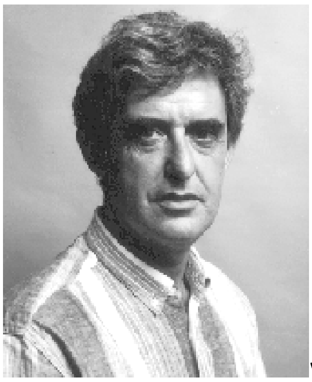
Conclusions

The intent of SEPP65 with respect to natural ventilation is to be commended. However, the manner in which cross-ventilation is mandated can create significant difficulties for designers. A mechanistic interpretation of the quantitative standards implicit in rules of thumb in the Residential Flat Design Code distracts from a proper evaluation of the likely ventilation performance of many apartments.

The natural ventilation issue has already been tested in the Land and Environment Court. In that setting, of course, the full complexity of predicted ventilation performance can be interrogated, and the Court is not backward in its preference for the more expert assessment. But it's a pity to add this to the Court's already excessive workload. It would be preferable if both designers and planning officers developed a more reasoned approach to design for natural ventilation of apartments.

In a more general sense, the difficulty of properly assessing natural ventilation in building proposals serves to illustrate a growing problem of assessing compliance for technical performance generally.

NEERG SEMINARS
CONTINUING EDUCATION FOR THE MANAGEMENT OF THE BUILT ENVIRONMENT



Steve King B.Arch Dip.Bdg.Sc.

teaches design, thermal comfort and building services in the Architecture program at the University of New South Wales, and is Deputy Director of the Centre for a Sustainable Built Environment (SOLARCH).

As a practice oriented member of the research team at SOLARCH, and with his specialisation in passive environmental control of buildings, Steve King has been responsible for projects affecting the evolution of energy performance expectations for both domestic and institutional buildings in Australia. He provides the technical oversight of the NSW HERS Management Body, which accredits assessors under the National House Energy Rating Scheme, NSW, and of a number of studies for the SEDA NSW to improve the implementation of minimum energy performance requirements for dwellings. He is the principal author of *SITE PLANNING IN AUSTRALIA: Strategies for energy efficient residential planning*, published by AGPS—and of the RAIA Environment Design Guides on the same topic. Through UNISEARCH, Steve conducts training in solar access and overshadowing assessment for Local Councils, and as part of professional development courses.

He is a Chartered Architect and maintains a specialist architectural consultancy in Sydney and Canberra.

Contact:

Steve King

SOLARCH *UNSW Sydney NSW 2052*

phone 9385 4851   fax 9385 4057   mobile 0414 385485

e-mail: stevek@unsw.edu.au