Peer review of Alternative Natural Ventilation – Building 2

Approach

The approach applied is generally consistent with the requirements of the City of Sydney's draft Alternative natural ventilation of apartments in noisy environments Performance pathway guideline.

The performance pathway requires that any apartment with alternative natural ventilation devices provide a minimum amount of natural ventilation for a minimum proportion of all hours in the year. The ventilation device is also required to be sufficiently detailed to confirm that it can provide the necessary unobstructed natural ventilation rates and provisions for control, cleaning, and routine maintenance. As the application of alternative natural ventilation devices is likely to impact floor space or ceiling depth requirements, it is usually necessary to resolve sizing requirements before development consent is granted.

The solution for alternative natural ventilation proposed is to use a relatively compact acoustical treated vertical plenum in each habitable room. The plenum size has been standardised for all apartments, with size being established to ensure that the worst-case application meets the minimum ventilation requirements. As the worst case is seen to perform at the minimum requirement, any increased resistance to airflow within the plenum as the design develops will result in either a non-compliant alternative natural ventilation proposal or planning impacts due to larger plenums being required.

This peer review considered the alternative natural ventilation context against the main aspects of design being, calculating minimum ventilation rates, aerodynamic characteristics of the plenum, and specification of design requirements.

Calculation of minimum ventilation rates within apartments

The method employed for calculating minimum airflow rates in the apartment is consistent with the performance pathway requirements.

All apartments have been designed to achieve minimum ventilation rates for 90% of all hours per year, which is suitable for single aspect or corner apartments. Minimum ventilation rates have been reviewed and found to be consistent with the requirements.

The modelling software applied for bulk airflow testing is appropriate, and the inputs for weather data, terrain, and wind sheltering according to the performance pathway requirements.

Vertical devices are subject to buoyancy forces, and therefore the assumptions of heating and cooling usage will influence the results. The heating and cooling control bands used in the modelling for living rooms and bedrooms are reasonable.

The acoustically treated vertical plenum has been modelled as a geometric opening 2.7 m tall and .575 m wide with an openable area of 11.75%, which is derived from CFD modelling that is reviewed below. The software used, MacroFlo, applies a default fixed discharge coefficient of 0.62, which is consistent with a sharp-edged orifice. The openable area is expressed as a percentage of the gross opening area defined in the model geometry, which provides an equivalent area of 0.18m2 per device and within is expected bounds.

The calculation of minimum airflow within the apartments and each habitable room demonstrates the performance pathway requirements are met. It is noted that the results are dependant of the correct calculation of the resistance to air through the acoustically treated vertical plenum, which is dealt with separately in the report and is simply an input to bulk airflow testing.

The report does not verify that non-acoustically treated unobstructed windows opening of sufficient size are provided to meet the balance of the 5% of habitable range served guided by ADG. This is a necessary aspect of an alternative ventilation system and must be demonstrated to comply with the performance pathway.

Calculation of plenum performance

Computational Fluid Dynamics (CFD) has been applied to calculate airflow resistance for the proposed plenum arrangement. The CFD model is abstracted to establish the resistance to airflow under a test condition of constant pressure on either side of the plenum and does not consider any influence of the apartments or design context. This approach is reasonable.

CFD is highly sensitive to the correct specification of boundary conditions and the equations employed in the solver. The CFD software solver employed is suitable for the task, although it is noted that buoyancy has not been considered. This is acceptable for calculating resistance as an effective loss of capacity due to bidirectional flow in the device is expected to be adequately dealt with in the bulk airflow model. The meshing applied is shown in a single plane and considered reasonable.

The performance of louvres and dampers appears to modelled as a function of geometry. The results are therefore totally dependant of the geometry described as opposed to a broad allowance for resistance. The method of calculating the performance of the fly screen is not described.

A convergence graph is shown for the key variable residual errors. The graph is presented at 300 iterations. It is assumed this is also the timestamp at which the results are taken. The graph shows some initial instability in the calculations, and we recommend additional iterations to confirm that the solution has converged.

Results of the CFD calculations are shown for pressures but not airflows or velocity vectors. Airflow plots would add considerable weight and provide confidence to the results.

The CFD modelling is critical to confirm the plenums' size, and the uncertainties in the reporting introduce a risk that sizing may need to change in design development. We have undertaken hand calculations of air resistance through a plenum with standard allowances for pressure drop for the various obstructions to airflow (refer table below). The empirical calculations estimate an equivalent area ratio of 6.6%, which is approximately 45% lower than the CFD calculated value used in the bulk airflow calculations. The empirical calculations are limited when applied to components in a compact arrangement. However, the difference in results found requires that the CFD modelling uncertainties are resolved before they can be fully relied upon. The requirement to resolve the modelling is confirmed by equivalent area derived from the CFD calculations and used in the bulk airflow calculations being matched by the louvre and fly screen components individually without any additional losses from the other components.

Building 2	Geometric Area (m2)	Discharge Coefficient (Cd)	Effective Area (m2)	Equivalent Area (m2)	**Equivalent Area Ratio**
External Mesh + dirt	1.5525	0.275	0.426	0.699	0.450
External Louvre	0.324	0.354	0.115	0.188	0.580
Flyscreen + dirt allowance	0.325	0.336	0.109	0.179	0.550
Damper	0.3075	0.549	0.169	0.277	0.900
Internal Louvre	0.324	0.403	0.130	0.214	0.660
Total Assembly	1.5525		0.062	0.102	**0.066**

Empirical calculation check of the equivalent area provided by the proposed plenum.

Specification of design requirements

The plenum's design requirements are given in the drawing BLD2-AC-NV-D1 rev 003 contained within the Noise and Vibration Impact Assessment report.

The various functional components are dimensioned in the drawing, and a percentage open nominated for each. The diagram is not clear about whether the percentage open quoted is applied as a geometric opening or equivalent area for ventilation. The latter is required and should be correctly specified.

Additional component selections are published after the diagram to complete the specification. The damper specified is wrongly orientated for the design and is also incompatible in dimensions. The internal plan dimension allowed within the plenum for the damper is 125mm. However, the specified two-blade damper (which is to be mounted on its side) is 170mm. If the damper were to be installed in the space drawn, the effective open area would reduce significantly, as would the plenum's performance.

Insect mesh is specified with a relatively high 68% open and is supported by a geometric free area calculation based on a Cyclone brand insect screen. A noted in the prior section; it is not clear how this has been translated into aerodynamic performance for the CFD modelling of total plenum residence. We also note these figure quoted does not allow for air increase in resistance for the build-up of dust and dirt.

The internal grille open area allowance appears reasonable, subject to architectural acceptability, but the table of dimensions is erroneously published from an unrelated project. The grille referenced is too wide to fit within the plenum specified.

The specification of alternative natural ventilation requirements does not address how a resident will control or close the plenum or internal access for cleaning and routine maintenance. These are important design aspects to ensure a meet the requirements of the guidelines. The applicant should confirm these arrangements before any approval as they could materially impact the proposed design and minimum rates of ventilation provided.

Peer review of Alternative Natural Ventilation – Building 4

Approach

The approach applied is generally consistent with the requirements of the City of Sydney's draft Alternative natural ventilation of apartments in noisy environments Performance pathway guideline.

The performance pathway requires that any apartment with alternative natural ventilation devices provide a minimum amount of natural ventilation for a minimum proportion of all hours in the year. The ventilation device is also required to be sufficiently detailed to confirm that it can provide the necessary unobstructed natural ventilation rates and provisions for control, cleaning, and routine maintenance. As the application of alternative natural ventilation devices is likely to impact floor space or ceiling depth requirements, it is usually necessary to resolve sizing requirements before development consent is granted.

The solution for alternative natural ventilation proposed is to use a relatively compact acoustical treated vertical plenum in each habitable room. The plenum size has been standardised for all apartments, with size being established to ensure that the worst-case application meets the minimum ventilation requirements. As the worst case is seen to perform at the minimum requirement, any increased resistance to airflow within the plenum as the design develops will result in either a non-compliant alternative natural ventilation proposal or planning impacts due to larger plenums being required.

This peer review considered the alternative natural ventilation context against the main aspects of design being, calculating minimum ventilation rates, aerodynamic characteristics of the plenum, and specification of design requirements.

Calculation of minimum ventilation rates within apartments

The method employed for calculating minimum airflow rates in the apartment is consistent with the performance pathway requirements.

All apartments have been designed to achieve minimum ventilation rates for 90% of all hours per year, which is suitable for single aspect or corner apartments. Minimum ventilation rates have been reviewed and found to be consistent with the requirements.

The modelling software applied for bulk airflow testing is appropriate, and the inputs for weather data, terrain, and wind sheltering according to the performance pathway requirements.

Vertical devices are subject to buoyancy forces, and therefore the assumptions of heating and cooling usage will influence the results. The heating and cooling control bands used in the modelling for living rooms and bedrooms are reasonable.

The acoustically treated vertical plenum has been modelled as a geometric opening 2.7 m tall and .575 m wide with an openable area of 11.75%, which is derived from CFD modelling that is reviewed below. The software used, MacroFlo, applies a default fixed discharge coefficient of 0.62, which is consistent with a sharp-edged orifice. The openable area is expressed as a percentage of the gross opening area defined in the model geometry, which provides an equivalent area of 0.18m2 per device and is within expected bounds.

The calculation of minimum airflow within the apartments and each habitable room demonstrates the performance pathway requirements are met. It is noted that the results are dependant of the correct calculation of the resistance to air through the acoustically treated vertical plenum, which is dealt with separately in the report and is simply an input to bulk airflow testing.

The report does not verify that non-acoustically treated unobstructed windows opening of sufficient size are provided to meet the balance of the 5% of habitable range served guided by ADG. This is a necessary aspect of an alternative ventilation system and must be demonstrated to comply with the performance pathway.

Calculation of plenum performance

Computational Fluid Dynamics (CFD) has been applied to calculate airflow resistance for the proposed plenum arrangement. The CFD model is abstracted to establish the resistance to airflow under a test condition of constant pressure on either side of the plenum and does not consider any influence of the apartments or design context. This approach is reasonable.

CFD is highly sensitive to the correct specification of boundary conditions and the equations employed in the solver. The CFD software solver employed is suitable for the task, although it is noted that buoyancy has not been considered. This is acceptable for calculating resistance as an effective loss of capacity due to bidirectional flow in the device is expected to be adequately dealt with in the bulk airflow model. The meshing applied is shown in a single plane and considered reasonable.

The performance of louvres and dampers appears to modelled as a function of geometry. The results are therefore totally dependant of the geometry described as opposed to a broad allowance for resistance. The method of calculating the performance of the fly screen is not described.

A convergence graph is shown for the key variable residual errors. The graph is presented at 300 iterations. It is assumed this is also the timestamp at which the results are taken. The graph shows some initial instability in the calculations, and we recommend additional iterations to confirm that the solution has converged.

Results of the CFD calculations are shown for pressures but not airflows or velocity vectors. Airflow plots would add considerable weight and provide confidence to the results.

The CFD modelling is critical to confirm the plenums' size, and the uncertainties in the reporting introduce a risk that sizing may need to change in design development. We have undertaken hand calculations of air resistance through a plenum with standard allowances for pressure drop for the various obstructions to airflow (refer table below). The empirical calculations estimate an equivalent area ratio of 6.6%, which is approximately 45% lower than the CFD calculated value used in the bulk airflow calculations. The empirical calculations are limited when applied to components in a compact arrangement. However, the difference in results found requires that the CFD modelling uncertainties are resolved before they can be fully relied upon. The requirement to resolve the modelling is confirmed by equivalent area derived from the CFD calculations and used in the bulk airflow calculations being matched by the louvre and fly screen components individually without any additional losses from the other components.

Building 4	Geometric Area (m2)	Discharge Coefficient (Cd)	Effective Area (m2)	Equivalent Area (m2)	**Equivalent Area Ratio**
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Total Assembly	1.5525		0.062	0.102	**0.066**

Empirical calculation check of the equivalent area provided by the proposed plenum.

Specification of design requirements

The plenum's design requirements are given in the drawing BLD2-AC-NV-D1 rev 003 contained within the Noise and Vibration Impact Assessment report.

The various functional components are dimensioned in the drawing, and a percentage open nominated for each. The diagram is not clear about whether the percentage open quoted is applied as a geometric opening or equivalent area for ventilation. The latter is required and should be correctly specified.

The specification for alternative natural ventilation devices is inadequate as there are no details of individual components provided beyond the single annotated diagram. The specification of alternative natural ventilation requirements does not address how a resident will control or close the plenum or internal access for cleaning and routine maintenance. These are important design aspects to ensure a meet the requirements of the guidelines. The applicant should confirm these arrangements before any approval as they could materially impact the proposed design and minimum rates of ventilation provided.