

What is ventilation?

- Ventilation is the intentional provision of fresh air and the removal of stale air.
- Ventilation is not the incidental leakage of air through the building fabric known as infiltration.

As we strive to reduce infiltration to improve energy efficiency, good ventilation design becomes more critical.

Effective ventilation is also critical in helping to minimise overheating during summertime.

Why is good ventilation so important?

‘A lack of ventilation can reduce productivity by at least 15% due to building related symptoms such as headaches, fatigue, irritated eyes and difficulty in concentrating.’

Source: David P. Wyon, 1996: "Indoor environmental effects on productivity", Proceedings of Indoor Air Quality (IAQ)'96

Guidance

- Approved Document F Means of Ventilation
- Building Bulletin 101 Ventilation of School Buildings
- CIBSE KS17 Indoor Air Quality and Ventilation
- CIBSE TM52 The Limits of Thermal Comfort
- CIBSE AM10 Natural Ventilation



How much ventilation do we need?

Subject to statutory requirements, for maximum energy efficiency we should aim to provide the minimum level of ventilation needed to:

- Maintain indoor air quality (IAQ) whilst avoiding cold draughts in winter.
- Minimise the risk of overheating without the need for air-conditioning in summer.

Indoor Air Quality

Many pollutants can be present in a building but in the absence of major contaminants, carbon dioxide (CO_2) levels are generally recognised as a key indicator of indoor air quality.

Atmospheric (CO_2) levels are typically up to 0.04% or 400ppm.

Guidance on indoor levels vary, for example:

- BB101 requires a daily average of <1500ppm in teaching and learning spaces.
- CIBSE recommend <900ppm based not on the impact of CO_2 on health or comfort but on the associated unacceptable levels of body odour.

Overheating

Guidelines on overheating also vary, for example:

- Building Regulations requires that a classroom should not exceed 28°C for more than 120 hours.
- CIBSE TM 52, “performance in use” criteria suggests the average internal to external temperature difference should not exceed 5°C.

The risk of a building overheating depends on a range of factors including:

- Heat gains
- The thermal properties of the building
- Occupancy patterns

What are the ventilation options?

- Natural
- Mechanical
- Hybrid or mixed mode

Why natural ventilation?

RIBA list benefits compared with mechanical ventilation as:

- Low running costs
- Zero energy consumption
- Low maintenance costs
- Probably lower initial costs
- Regarded as healthier
- Psychological benefits from connection to outside

Why natural ventilation?

CIBSE highlight benefits as:

- Lower energy costs through reduced energy consumption
- Reduced carbon emissions
- Decreased capital cost
- Decreased maintenance costs
- Reduced energy use associated with fans
- Fewer possible problems of plant noise

Categories of natural ventilation?

Natural ventilation systems are ultimately driven either by:

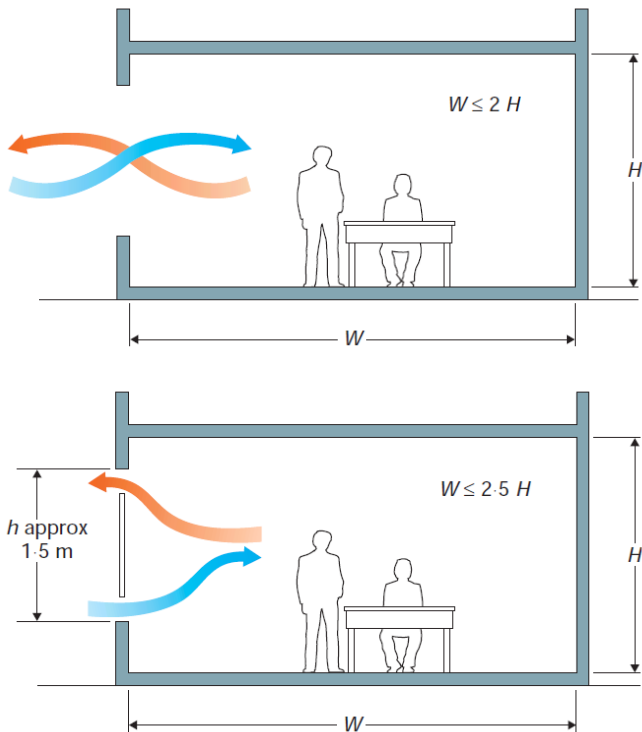
Wind Effect

- Single sided
- Double sided or cross ventilation
- Roof mounted ventilators

Stack Effect

- Passive stack
- Solar chimneys

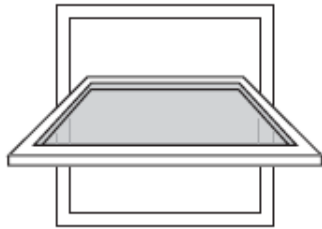
Single-sided ventilation



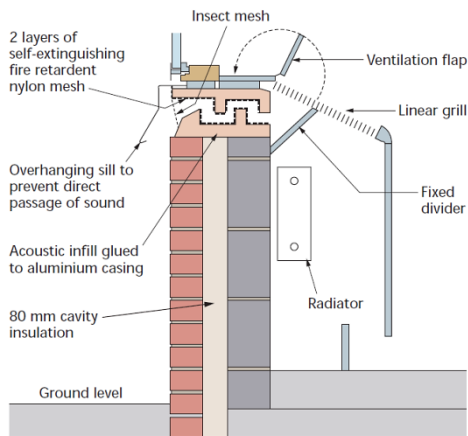
This layout is commonly found in cellular buildings. Wind turbulence is the main driving force in summer when using single ventilation openings.

Using multiple ventilation openings in the façade can enhance the ventilation rate due to buoyancy driven air movement. Separating the low level openings from the window can increase the effect but the potential for cold draughts should be addressed.

Ventilation openings

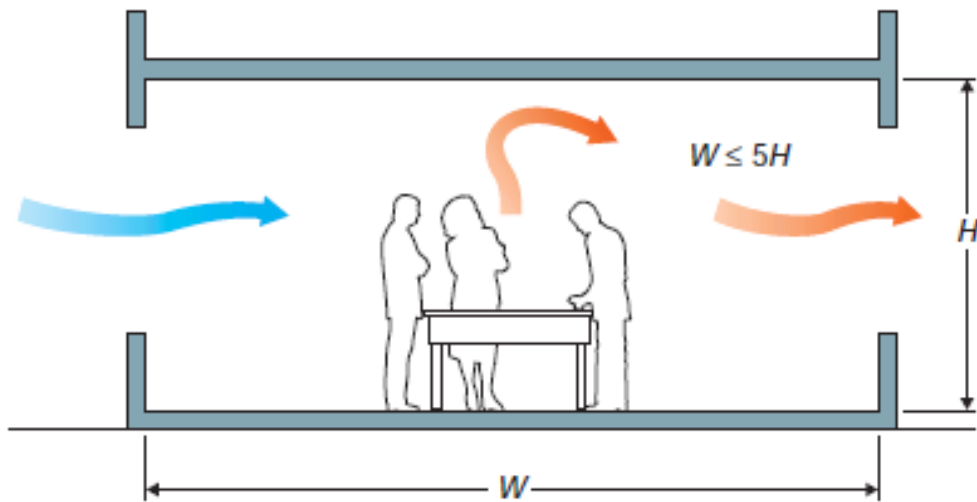


Window design greatly influences ventilation effectiveness e.g. horizontal pivot have a high ventilation capacity and promote good air distribution.



Purpose made louvred ventilation openings can be specified with fire-retardant and/or acoustic treatment and provide greater security. The potential for cold draughts can be minimised by using baffles within the wall liners and incorporating openings within or behind heat emitters.

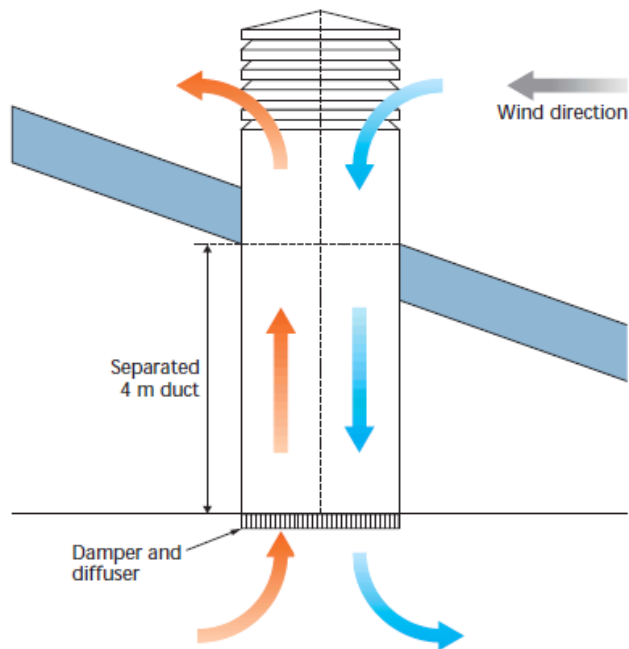
Double-sided or cross ventilation



The “rule of thumb” governing maximum width implies a narrow plan although a similar effect can be achieved in a deep plan layout with a courtyard.

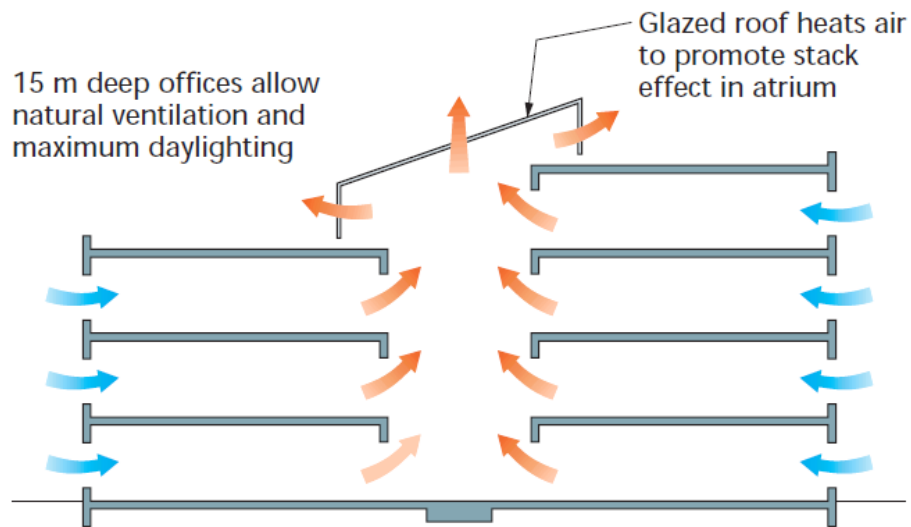
This approach also enhances the potential for natural light.

Cross ventilation using roof mounted ventilator



A multi-directional ventilator generates positive pressure on windward and negative pressure on leeward elevations. Dampers and diffusers control airflow and distribution.

Atrium stack ventilation



Possesses similar benefits to incorporating a courtyard but solar heating of atrium also provides stack effect and can also be used as year round social and or circulation space.

Solar chimneys

In this often quoted example at BRE's Environmental Building, glazed elements within the chimney are used to enhance temperatures within the stack further aiding buoyancy and hence increasing airflow rates.



Source: CIBSE AM10 Natural Ventilation in non-domestic buildings

Designing for natural ventilation

- Use narrow plan layouts where possible to maximise potential for natural ventilation and daylight.
- Incorporate an atrium or courtyard where deep plan layouts are unavoidable.
- Design to minimise solar and internal heat gains.
- Optimise ceiling heights to promote IAQ whilst avoiding costly mechanical ventilation and air-conditioning systems.
- Consider layouts sympathetic to the desired airflow paths.

Narrow plan layouts

- Ideal for single sided or cross ventilation.
- Maximises potential for natural light.
- However does suffer greater heat loss than other building forms.



Deep plan layouts

- Incorporating a courtyard or atria effectively makes the building narrow plan.
- Single-sided or cross ventilation is aided.
- Building benefits from increased natural light.
- Atria can also create stack effect and enhance cross ventilation.



Design to minimise heat gains (<40W/m²)

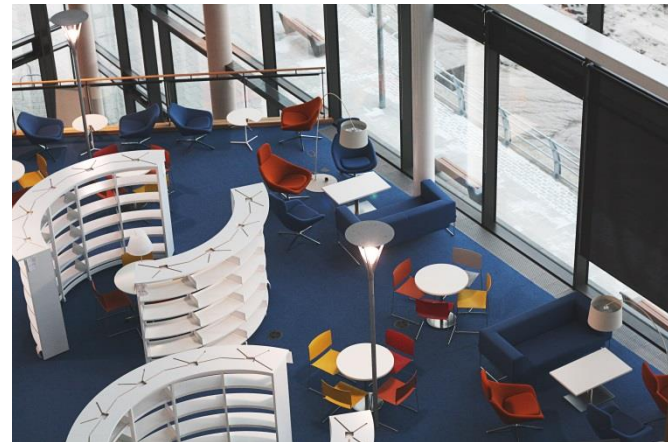
- Adopt an holistic approach by considering the building façade as an important element within the ventilation strategy.
- Integrate appropriate shading to minimise solar gain without reducing daylight.
- Reduce internal heat gains from lighting by good design and control to avoid over-lighting and unnecessary use.
- Specify low energy office equipment and site larger items away from people.
- Utilise thermal mass to absorb peak gains.



Optimise ceiling heights

Higher ceilings can;

- improve indoor air quality and reduce summertime temperatures within the occupied zone
- help to avoid the need for costly mechanical ventilation and air-conditioning, offsetting the higher build cost
- create an impression of space



Retro-fitting for natural ventilation?

Natural ventilation is already the norm in many of our existing buildings and is often combined with some form of mechanical ventilation (zoned mixed-mode) e.g. toilet extract.

Incorporating natural ventilation into refurbishment schemes can also be a viable option for reducing the size of or to replace existing mechanical systems.



Hybrid or mixed mode solutions

BSRIA state that:

‘The concept of an integrated approach using both natural and mechanical ventilation can provide a pragmatic low energy solution.’

Mixed mode systems

BSRIA offer the following categories:

- Contingency – mechanical ventilation is installed to provide in use flexibility
- Zoned – some areas, for example conference rooms, are supplied with mechanical ventilation
- Changeover – such as a mechanical system for summer/winter and natural ventilation in spring and autumn
- Parallel – both methods in use simultaneously

Controlling natural ventilation systems

Control systems are needed to determine the appropriate level of ventilation at all times to:

- Maintain indoor air quality (usually inferred by CO₂ levels) within a pre-determined value (e.g. 1500 ppm).
- Reduce the frequency of internal space temperatures exceeding acceptable levels (e.g. 28°C for x no. of hours).

BSRIA state that:

‘Ventilation systems require control to enhance occupant comfort and to minimise the building’s energy consumption. Automatic controls with an appropriate level of user override facility offer the greatest opportunity to achieve these aims.’

Controlling natural ventilation systems

Automatic controls routinely consider:

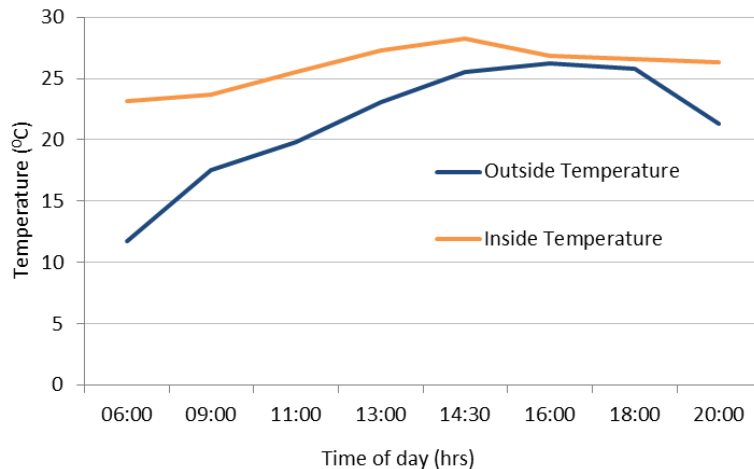
- Time and date
- Internal space temperature
- Indoor air quality (usually inferred from CO₂ levels)
- External air temperature
- Damper/window actuator position

More advanced systems may also consider:

- Occupancy
- System velocities/flow rates
- Wind speed and direction

Night cooling strategies

July 20th without night cooling



Source: IES model

Outside air can be used to cool buildings prior to occupancy when temperature differentials permit thereby reducing the frequency of overheating.

Can be applied to buildings with natural, mechanical or mixed-mode ventilation systems.

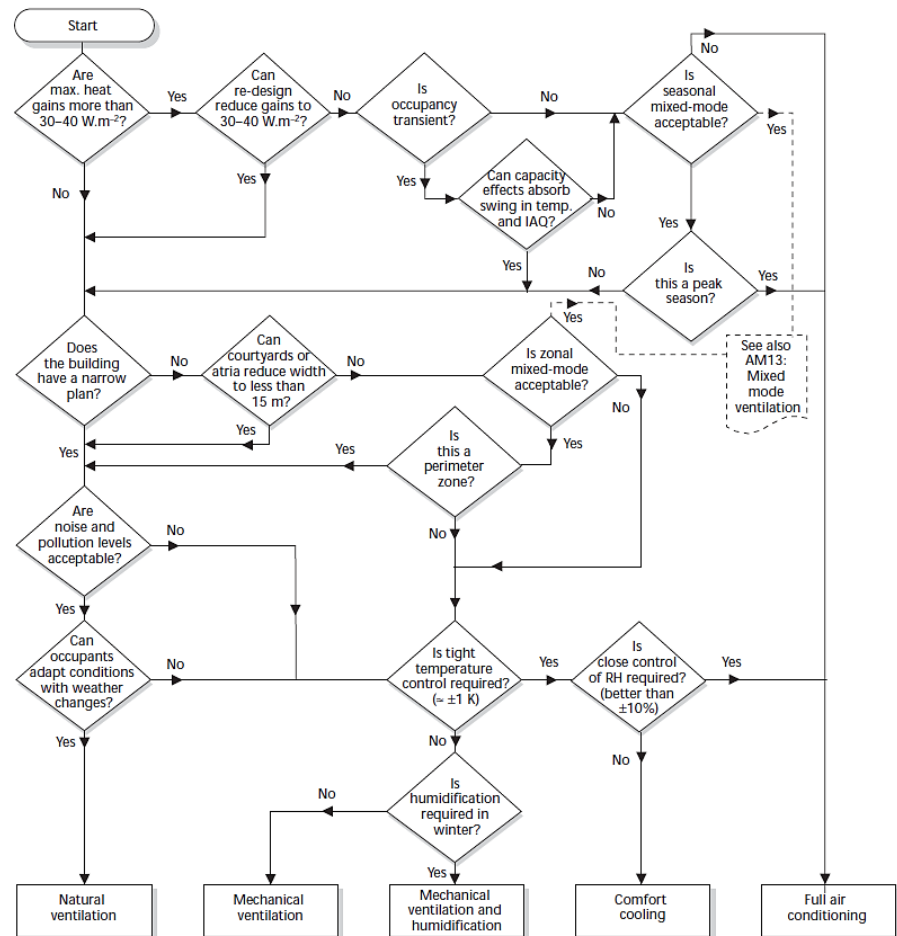
Is most effective in buildings with high thermal mass.

When to specify

Natural ventilation can cost less to:

- Install
- Operate
- Maintain

Decision trees can be helpful in assessing which strategy is most appropriate for your building.



Mechanical Ventilation

MV systems rely on fans to produce airflow and can be:

- Supply only
- Extract only
- Supply and extract

Mechanical Ventilation

MV can be primarily classified as:

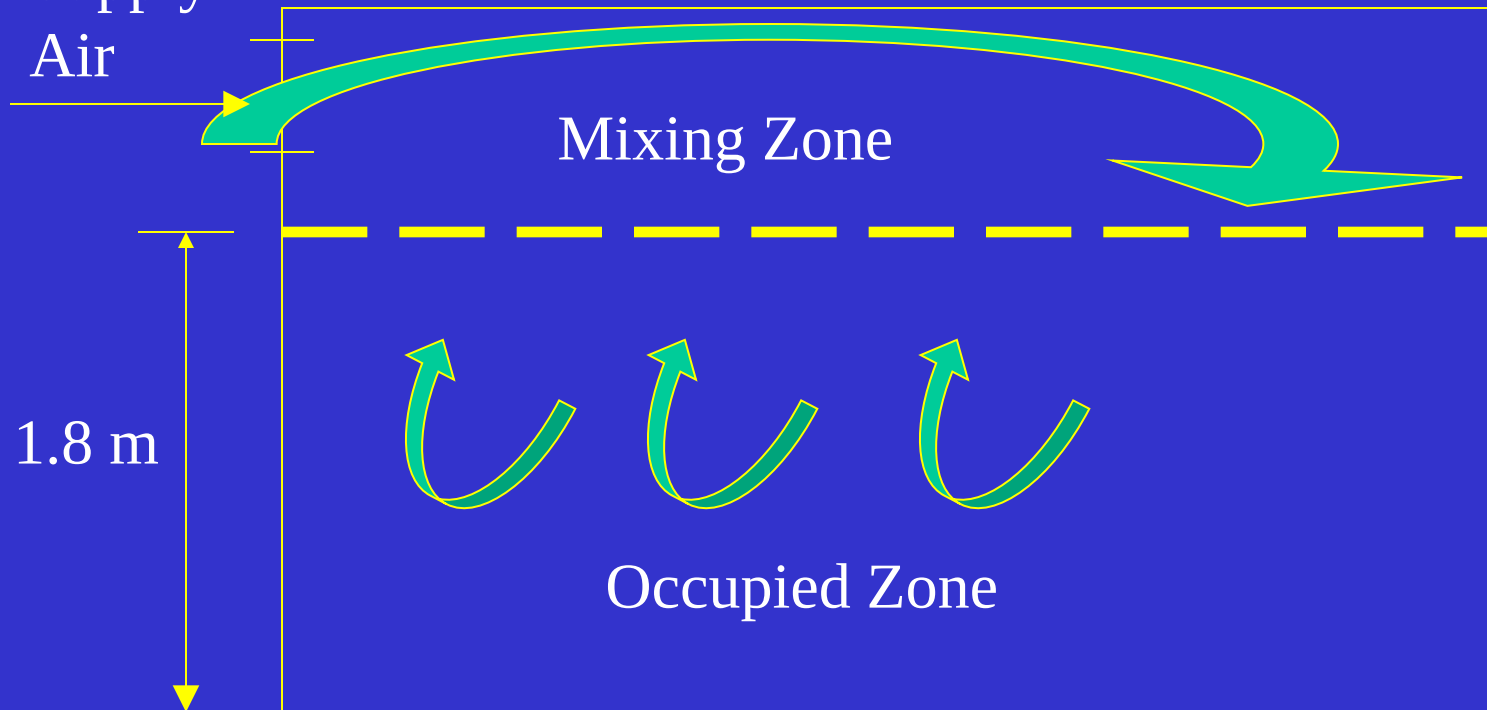
- Mixing
- or
- Displacement

Supply
Air

Mixing Zone

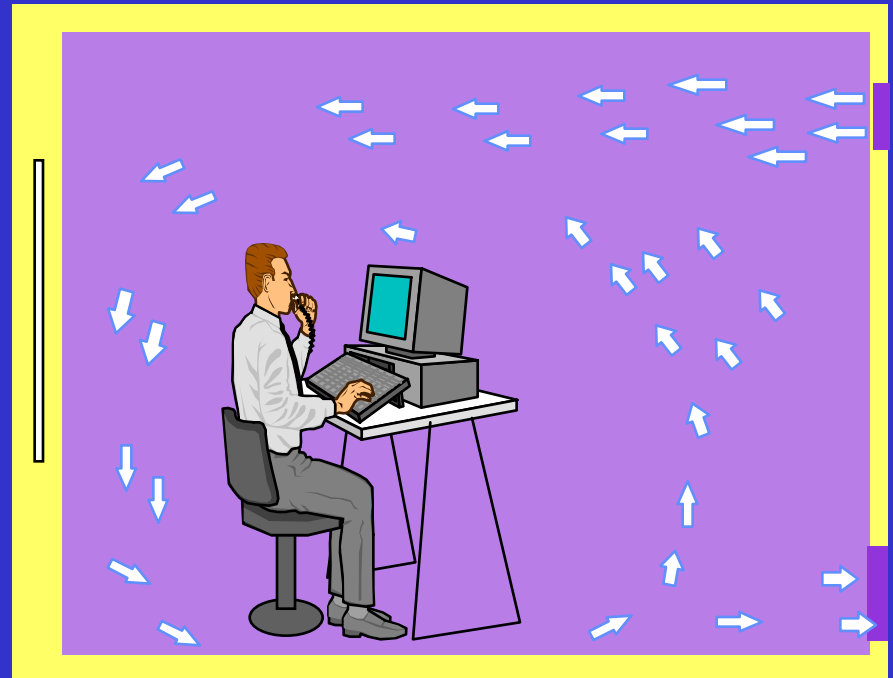
1.8 m

Occupied Zone



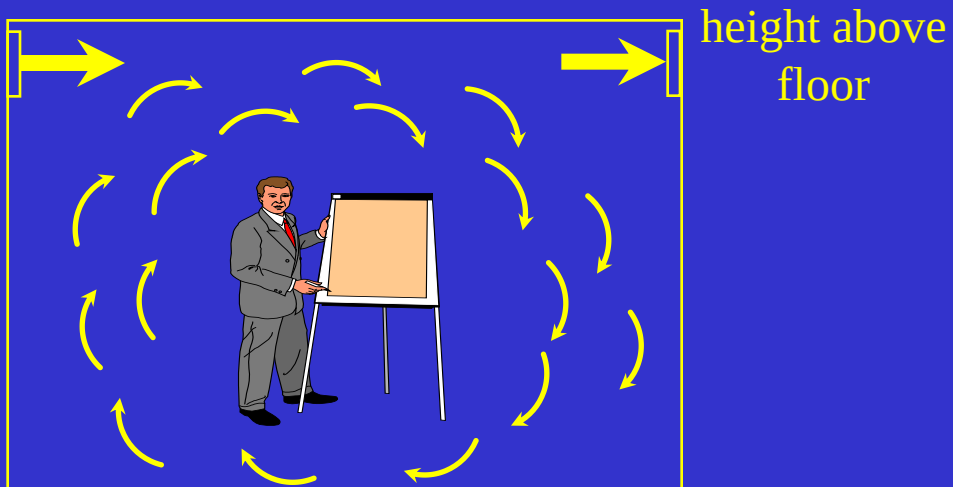


Displacement ventilation (DV)

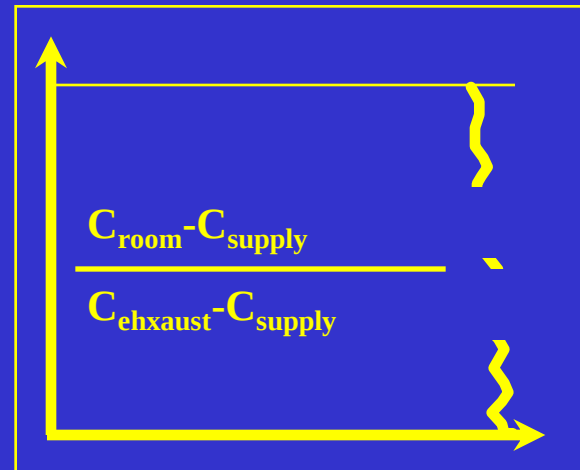


Mixing ventilation (MV)

The Principle of Displacement Ventilation

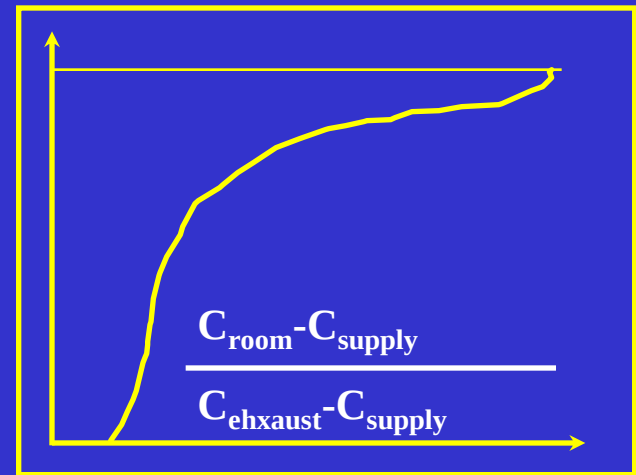


Mixed flow





height
above
floor



Displacement Ventilation

What is Displacement Ventilation

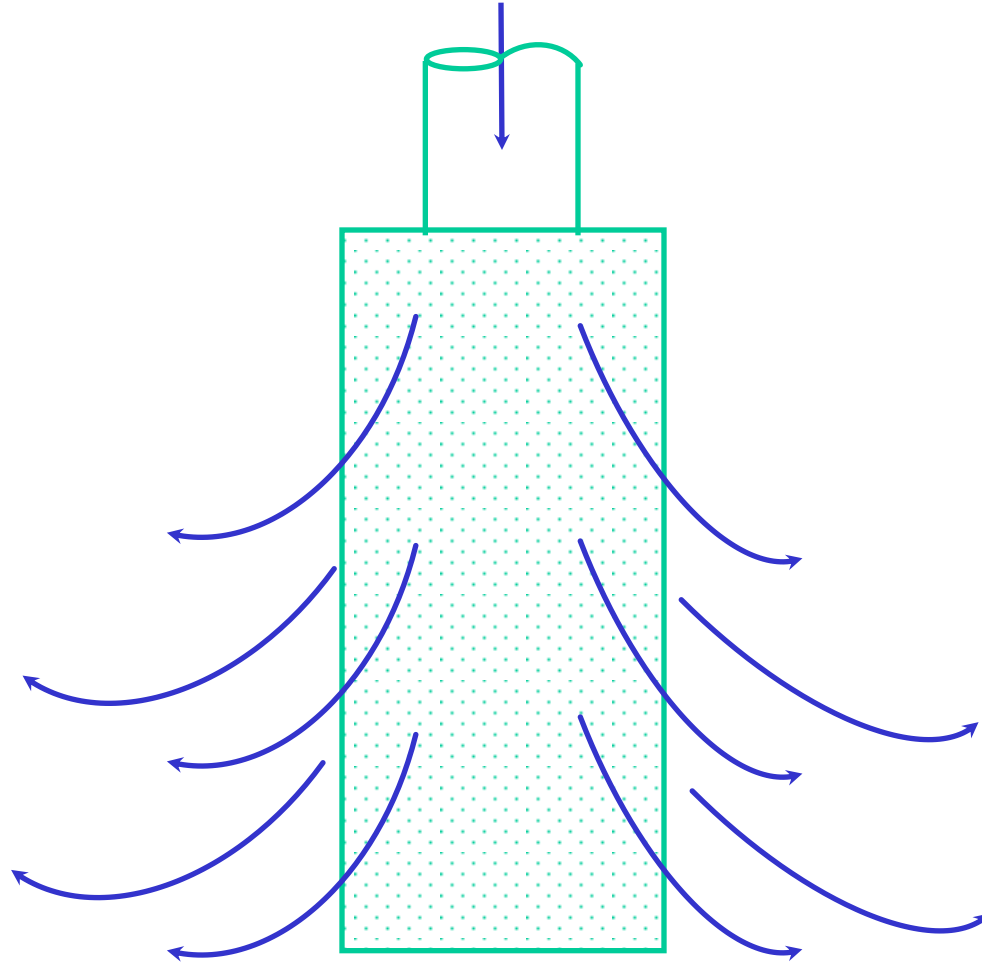
- The gentle introduction of “fresh air” at a temperature slightly below the design room temperature
- The supply air flows slowly over the floor and rises as it is warmed by occupants and objects within the room
- It displaces the contaminated air as it rises and is extracted at high level

Applications

Where:

- The supply air is cooler than the room air
- Contaminants are warmer and/or lighter than the surrounding air
- Surface temperatures of sources are high
- Disturbance to room airflows are weak
- Ceiling heights are high

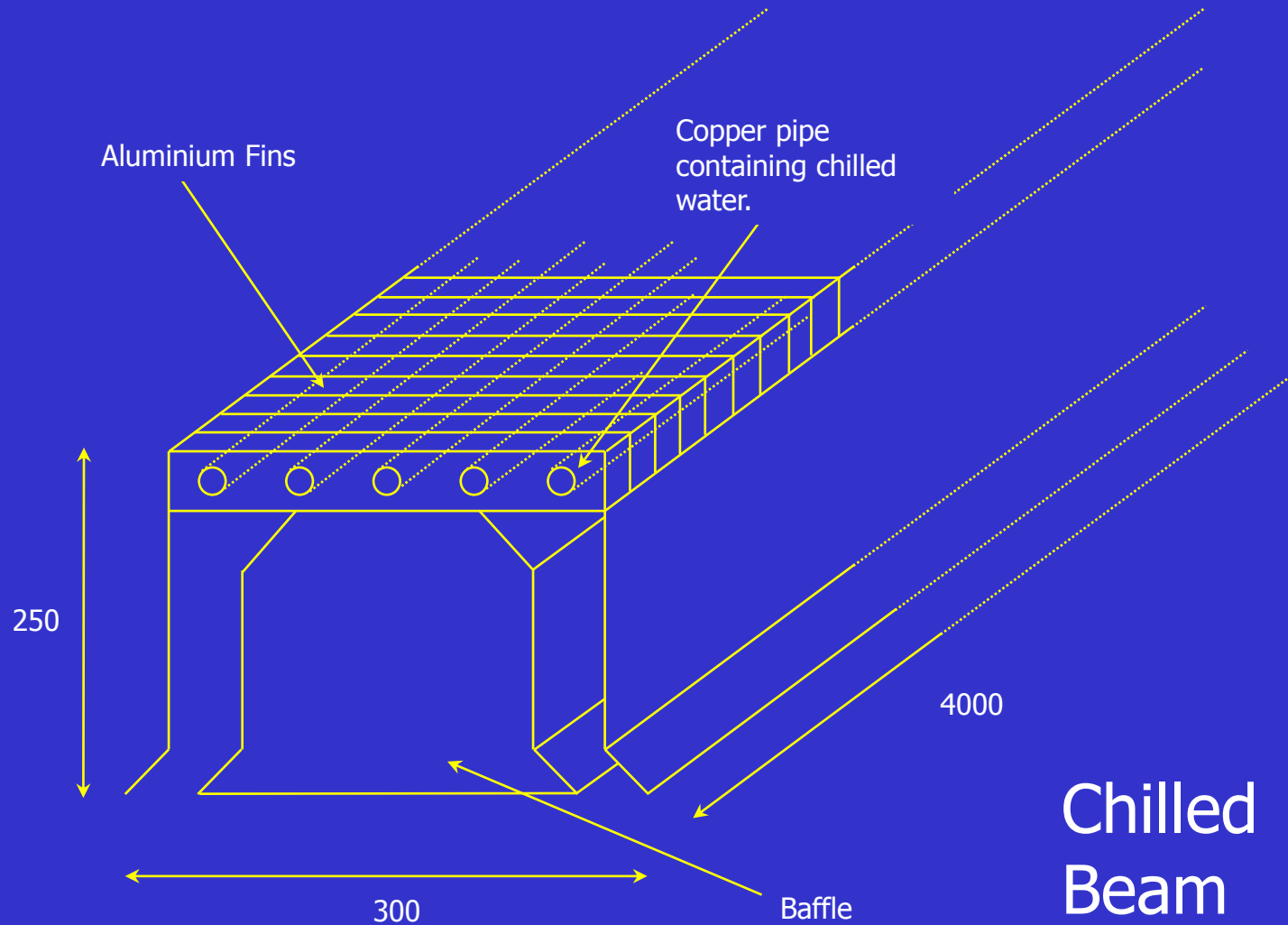
Displacement Ventilation



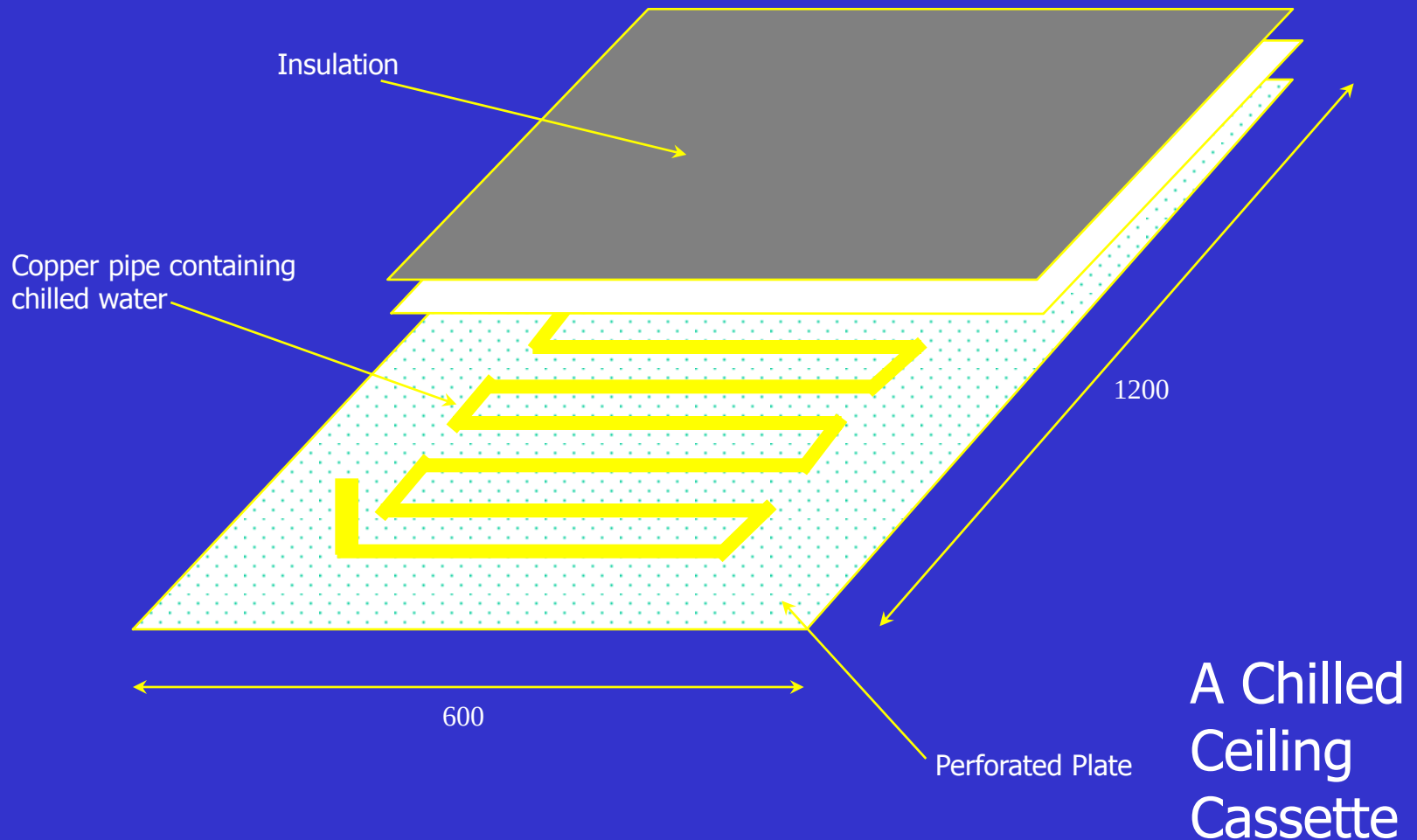
Limitations

- Indoor architecture
 - Geometry, size and location of air terminals
- Internal obstacles
 - Furniture partitions, desks, etc
- Thermal comfort
 - Draught zone around supply air terminals
 - Vertical temperature gradient
 - Low cooling capacity

Displacement Ventilation



Displacement Ventilation



Mixed Mode Ventilation

- **Supplementary** – fan used to assist natural ventilation
- **Complementary** – natural and MV work together to meet demand
- **Alternate** – natural ventilation and MV fitted, actual system used dependent on climatic and demand conditions