Workshop: What’s so Great about Natural Ventilation?

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Ventilation Solutions

Hybrid ventilation

Natural ventilation

Mechanical ventilation

Air Conditioning

Micro-climate

Building Design

Thermal Comfort

Occupant Profile

Outdoor Climate

Building Use

Internal loads

IAQ
Natural Ventilation Advantages

- No fans are needed and therefore no electricity use and a low noise level
- High user satisfaction because of a high degree of individual control of the indoor climate as well as a direct and visible response to user interventions
- Can be used for both ventilation and passive cooling
- Improved air quality outside heating season
- Has to be integrated with building design
- Easy to combine with other passive energy technologies like daylighting
Natural Ventilation Disadvantages

- Depend on outdoor climatic conditions (temperature, humidity)
- Natural driving forces can for longer periods be quite small, which limits possibilities for application of filtration and heat recovery, that might result in poor indoor air quality and/or increased energy use for heating
- Results in limitation in the choice of building layout
- Outdoor dust and traffic noise requires special solutions
- It is difficult to fulfill requirements to thermal comfort in winter if preheating of incomming air is not applied
- The air flow rate will always be dependent of the natural driving forces as well as the occupant’s control. This might result in an increased energy consumption
- The indoor temperature will variate more than for mechanical systems
### Natural Ventilation Principles

- Single-sided ventilation
- Cross ventilation (wind driven)
- Stack ventilation (thermal bouyancy)
- Combined cross and stack ventilation
Hybrid Ventilation Strategies

- Alternating or combined natural and mechanical ventilation
- Fan assisted natural ventilation
- Stack and wind supported mechanical ventilation
NCC Headquarters, Copenhagen, Denmark

Floor area: 7875 m$^2$
675 personer
NCC Headquarters, Copenhagen, Denmark

Openings in roof

Openings in facades on all floors

Stack ventilation through atrium
Floorplan

- 3 office zones/floor
- Atrium
- Service room and meeting rooms with mechanical exhaust
- Canteen balanced mechanical ventilation
B&O Headquarters, Struer, Denmark
Displacement Ventilation

Stack ventilation with chimney
Luftindtag og forvarmning
Air Exhaust System
Institute of Development Economies (JETRO), Chiba, J

Courtesy of:
Dr. Tomoyki Chikamoto, Nikken Sekkei Ltd, Japan
Hybrid Ventilation and Air Conditioning System

- Effective exhaustion of heat and pollutant
- High IAQ and thermal comfort

Key terms:
- EA (Exhaust Air)
- OA (Outside Air)
- Ambient Zone
- Task Zone
- Heat from Task Zone
- Pollutant from Task Zone
- Supply fan unit for Ambient Zone
- Personal supply outlet for Task Zone (Direct supply of fresh air to human body)
- Personal AC system for Task Zone
- Under-floor AC system for Ambient Zone

Temperatures:
- Ambient Zone: 22℃
- Task Zone: 26℃
Hybrid Ventilation and Air Conditioning System

**Automatically controlled window**
- This opening is also used for smoke exhaust opening in case of fire

**Ambient supply unit**

**Task supply unit**
- Air volume and direction are easily changed by each user
Control of Hybrid Ventilation and Air Conditioning System

Ambient zone is controlled mildly by central BA system for energy saving. Task zone is controlled by each one’s choice for human’s comfort.

Air volume and direction are easily changed by each user. Task supply unit is detachable.
Mediå School, Grong, Norway

Courtesy of:
Professor Per Olaf Tjelflaat, Norwegian University for Science and Technology, Trondheim, Norway
Air Supply System
Air Exhaust System
Mediå School, Grong, Norway

**Low Pressure loss in system**

- Ventilation supply about 35 pa
  - Filter about 15 pa
  - Heat recovery about 10 pa
  - Heating about 5 pa
- Ventilation exhaust about 20 pa
  - Heat recovery about 12 pa

**Total pressure loss**

- **Winter**
  - About 55 pa
- **Summer**
  - About 28 pa
Checklist

1. Building Orientation and Location
2. Building Layout
3. Building Constructions
4. Heat- and Contaminant Loads
5. Energy Use
6. Air Distribution Principles, Air Flows and Opening Types
7. Fire Safety
8. Acoustics and Noise (internal and external)
9. Daylight and Lighting Control
10. Security and Safety
11. Indoor Climate (thermal comfort and indoor air quality)
12. Control and operation
Natural Ventilation Applicability

- Issues related to building design
  - Location and orientation
    - Outdoor noise and air quality, sound attenuation, filtration, solar radiation, wind conditions
  - Layout
    - Roomheight, room depth, zoning, plan solution
  - Constructions
    - Facade solution, thermal mass
**Natural Ventilation Applicability**

- **Issues related to building use**
  - **Heat- and contaminant loads**
    - Solar radiation, personload, lighting, office equipment, choice of materials
  - **Energy use and thermal comfort**
    - Demand control, draught risk, heat recovery, night cooling
  - **Air distribution principles**
    - Location of inlets and outlets, ventilation efficiency
  - **Daylight**
    - Facade solution, solar shading, lighting control
  - **Fire, noise and safety**
<table>
<thead>
<tr>
<th>Parameters</th>
<th>High</th>
<th>Possible</th>
<th>Requires special solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glasarea in % of facadearea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Solar Shading</td>
<td>&lt; 25</td>
<td>25-50</td>
<td>&gt; 50</td>
</tr>
<tr>
<td>Internal Solar Shading</td>
<td>&lt; 15</td>
<td>15-25</td>
<td>&gt; 25</td>
</tr>
<tr>
<td>Surroundings (shielding, air quality, noise)</td>
<td>Suburb or light traffic load</td>
<td>City area or moderate traffic load</td>
<td>City Centre or heavy traffic load</td>
</tr>
<tr>
<td>Roomheight, m</td>
<td>&gt; 3.2</td>
<td>2.7-3.2</td>
<td>&lt; 2.7</td>
</tr>
<tr>
<td>Relation between Roomdepth/Roomheight</td>
<td>&lt; 2</td>
<td>2-5</td>
<td>&gt; 5</td>
</tr>
<tr>
<td>Activities with High Polution Load</td>
<td>In separate rooms</td>
<td>Partly in separate rooms</td>
<td>Distributed in rooms</td>
</tr>
<tr>
<td>Office Type</td>
<td>Cellular offices dominate</td>
<td>Mixed</td>
<td>Open plan offices dominate</td>
</tr>
<tr>
<td>Thermal capacity</td>
<td>Exposed thermal mass</td>
<td>Thermal mass</td>
<td>No thermal mass</td>
</tr>
<tr>
<td>Internal heatload, W/m²</td>
<td>&lt; 15</td>
<td>15-25</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>m² Nettoarea per Person</td>
<td>&gt; 13</td>
<td>8-13</td>
<td>&lt; 8</td>
</tr>
<tr>
<td>Criteria for Time of Reverberation</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Is Internal Noise Transport Acceptable?</td>
<td>Yes</td>
<td>Occasionally</td>
<td>No</td>
</tr>
<tr>
<td>Are Openings Allowed in Envelope?</td>
<td>Yes, always</td>
<td>Yes, always</td>
<td>Only during occupation</td>
</tr>
<tr>
<td>Dress Code</td>
<td>Informal</td>
<td>Formal</td>
<td>Formal</td>
</tr>
<tr>
<td>Smoking</td>
<td>Not allowed</td>
<td>Allowed in special rooms</td>
<td>Allowed</td>
</tr>
<tr>
<td>Deteriorated IAQ in Periods</td>
<td>Acceptable</td>
<td>Only in short periods</td>
<td>Not acceptable under extreme conditions</td>
</tr>
<tr>
<td>Is Draught Acceptable?</td>
<td>In short periods</td>
<td>In short periods</td>
<td>Only in short periods under extreme conditions</td>
</tr>
<tr>
<td>Average Air Change Rate in Winter, h⁻¹</td>
<td>&lt; 1</td>
<td>1-2</td>
<td>&gt; 2</td>
</tr>
</tbody>
</table>
Desirable Features

- "Open" building design (allow for internal air flows)
- Limited room depth
- Increased room heights (thermal and pollution buffer)
- High thermal mass (efficient night ventilation)
- Efficient solar shading (control of external loads)
- Low energy equipment, daylighting and control of efficient artificial lighting (low internal loads)
- Low emitting materials and zoning of activities and equipment (low pollution load)
### Characteristics of Efficient Building Integrated Ventilation Solutions

- Reduction of air change rates through emission and demand control
- Heating through a combination of passive (solar radiation, internal loads) and/or active technologies
- Cooling through a combination of natural (outdoor air, ground coupling) and mechanical cooling technologies
- Considerable reduction of pressure loss through utilisation of the building for distribution of air
- Transport of air through a combination of natural and mechanical driving forces
- Utilisation, redistribution, storage and/or reduction of internal heat loads and solar radiation