Building name: Jaer School  
Year of completion: 1999  
Type of building: Educational

Design Team: Grinde AS (architects); Axlander & Rosell AS (HVAC consultant); NBI (natural ventilation design/ indoor climate specialists); Ilje AS (project management); and other consultants

Site data

<table>
<thead>
<tr>
<th>Design conditions</th>
<th>Design conditions</th>
<th>Average wind speed</th>
<th>Prevailing wind direction</th>
<th>Terrain shielding</th>
<th>Dust pollution</th>
<th>Noise pollution</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>winter °C g/kg</td>
<td>summer °C g/kg</td>
<td>2.17 m/s</td>
<td>NNE</td>
<td>Half open</td>
<td>Low</td>
<td>Moderate</td>
<td>59.90 °N</td>
<td>10.73 °E</td>
<td>103</td>
</tr>
</tbody>
</table>

Design philosophy for IAQ and thermal comfort, and other issues of concern

The following cost-effective sustainable technologies ensure a high IAQ and thermal comfort, with minimal use of energy:

- Displacement ventilation to maximise ventilation efficiency. The air is preheated when necessary, to reduce the risk of draught in cold periods, and hence maintain thermal comfort.
- Demand-controlled ventilation (CO₂), combined with hybrid ventilation, to minimise energy consumption for ventilation. This is achieved by continuous ventilation by passive stack effects and/or an assisting fan.
- In Norway, it is particularly important to save electrical energy, hence low-temperature (40-60°C) hydronic
heating was chosen, enabling the possible future use of a heat pump.

- Heavyweight, solid construction for thermal storage
- Low-emissivity materials. This improves IAQ whilst enabling reduced air flow rates.
- Large volumes and ceiling heights, to act as a buffer, reducing peaks in demanded flow rate.

Other design concepts were:

- Focus on ease of maintenance and a minimum of technical installations
- Low noise

Principle of hybrid ventilation

The ventilation is predominantly stack-driven natural ventilation, since the outdoor temperature is below room temperature for most of the year. The aerodynamic exhaust towers exploit wind to create a negative pressure irrespective of wind direction, though this effect is much smaller than the stack effect. Fan assistance is used during periods when the stack effect and wind are not strong enough for natural ventilation. The single fan is placed in the culvert in the basement. Each classroom has its own exhaust tower with a damper to control airflow rate. The building must therefore be satisfactorily airtight in order to achieve the desired ventilation rate and energy efficiency.

In summer, supplementary ventilation and cooling may be provided by manually opening windows in the facade.

Components used to solve main issues or problems

**IAQ control**: Airflow to each classroom is controlled by the motorised weatherproof opposed-blade damper in the room’s ventilation turret. The CO\textsubscript{2} sensor in each classroom is placed just above breathing height of the seated kids, about 1 m high. Coarse particles fall from the air in transit thought the long culvert.

**Temperature control**: A temperature sensor is placed outdoors and in each classroom. The occupants can increase the air change rate by opening the windows, which is anticipated only during summer to prevent overheating. All year round, the culvert system provides the minimum fresh air requirements. Low-temperature hot water radiators provide perimeter heating in winter. A heating battery in the culvert preheats supply air to 15°C when necessary.

**Energy conservation**: Displacement ventilation diffusers for increased ventilation efficiency. Demand-controlled ventilation where the CO\textsubscript{2} set-point is temperature compensated to conserve energy at extreme winter temperatures (Max 1500ppm at -15°C outside, Min 1000ppm at +10°C outside). Motorised dampers in each ventilation stack. Low-\textsuperscript{2} gas-filled double glazing and well insulated walls and roof. Thermostatic radiator valves. BEMS for better energy management. The underground culvert is ca. 2x2m and 60m long, and has a surface area of well over 300m\textsuperscript{2} high-thermal-mass concrete. The culvert damps daily temperature swings of the incoming fresh air, reducing the need for preheating, and reducing the need for mechanical cooling; the storage effect is greatest for weekly or monthly swings. The seasonal storage capacity is approx. 3-4000kWh; this comes in addition to significant diurnal storage effect. The room height and volume per pupil is bigger than typical schools. This larger volume acts as a ventilation buffer. Hot water for heating is low-temperature water from oil boiler or electric boiler; the boiler used depends on spot energy price, but there are future plans for a ground-water heat pump.

**Ensuring low pressure drops**: Using large cross-sections for ventilation ducts and large components for air handling. There is no fine filter or heat recovery battery.

**Draughts**: Problematic draughts are avoided by using low-velocity supply diffusers and by radiators below windows.

**Fire regulations**: Solar chimney dampers fully closed under fire alarm conditions. Smoke/fire alarm system.

**Maintenance**: Operations & Service manuals tailor-made for the building. The caretaker has periodical inspection and supervision by BEMS. Modern, drier, less chemical-intensive cleaning methods are used.

Control Strategies

The control system is a centralised supervisory control (BEMS). In principle, operation is by the centralised system. The type of management is internal by caretaker, or remotely via modem.

There are 4 main operation modes, depending on two bimodal parameters. (1) Preheating needed, (2) Preheating not needed though cooling possibly needed, (A) Day, (B) Night. There is nighttime ventilation for precooling in summer.

When the CO\textsubscript{2} level or temperature in a room rises above set-point value, the damper opens gradually. If the CO\textsubscript{2} level remains above the set-point, then the fan is started. The 1m axial fan is frequency-controlled to maintain constant over-pressure in the culvert. The pressure set-point needs fine-tuning.

Overall performance

The building was completed on time and on budget. The total cost (€ 2330/m\textsuperscript{2}) is above the average for schools (€1460–1830/m\textsuperscript{2}), due mostly to its heavyweight structure instead of wood, though the HVAC system cost (€ 200/m\textsuperscript{2}) is slightly below average. A measurement programme commenced autumn 1999. The teachers and pupils are very satisfied with the indoor environment. One can notice slight traffic noise from the turrets when fully open.