**MEDIÅ SCHOOL, GRONG, NORWAY**

<table>
<thead>
<tr>
<th>Building name:</th>
<th>Mediå school</th>
<th>Year of completion:</th>
<th>1998</th>
<th>Type of building:</th>
<th>Elementary school</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Team:</strong></td>
<td>Kåre Herstad, Letnes Arkitekter AS, Karin Buvik, Anne Grethe Hestnes, Øyvind Aschehoug and Barbara Matusiak, SINTEF. Eystein Rødahl and Per Olaf Tjelflaat, NTNU.</td>
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**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 T g/kg T</td>
<td>summer T g/kg T</td>
<td>(m/s)</td>
<td>SE &amp; NW</td>
<td>In valley</td>
<td>Low</td>
<td>Low</td>
<td>65 N</td>
<td>11 E</td>
<td>50</td>
</tr>
</tbody>
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**Design philosophy for IAQ and Thermal Comfort and issues of concern for this building**

The Grong school is a new single-storey building of 1000 m², designed to accommodate 223 occupants. The glazed envelope area is approximately 300 m², with a glazing U-value of 1.6 W/m².K. The maximum ventilation flow rate is approximately 2.8 m³/s.

The goals for quality of the indoor environment are to achieve less than 10% dissatisfied and to avoid exposure that can result in short-term or long-term health risks among the occupants.

Low-emissivity materials, displacement ventilation, demand-controlled ventilation and heat recovery of exhaust air has been applied in order to ensure a satisfying indoor environment combined with the lowest possible energy consumption for ventilation.

Daylighting, using skylights, has been installed for all classrooms to improve the indoor environment and to reduce electric energy consumption for artificial lighting.
Electric energy is, in some countries, more expensive than other alternatives for energy supply to a building. And that price difference is expected to rise in the future. Hence, it has been an issue in this project to save electric energy.

**Principle of hybrid ventilation**

The outdoor climate at the site has temperatures below indoors for 95% of the year. There is no steady wind of acceptable strength on the site. Thus, buoyancy-driven ventilation assisted by fans has been chosen for this project. The building has an exhaust tower that has been designed to utilize wind force when available and to avoid entrance of outdoor air. Hence, heat exchanger units placed in the tower for recovery are expected to show high efficiency. The resulting height of heated air column in the building is about 10 m. The ventilation airflow path through the building is sized to allow for velocities up to around 1 m/s. Hence, components like filter and heat exchanger units are much larger than those used for regular mechanical ventilation systems. To overcome the total pressure drop, frequency-controlled fans are installed at the ventilation intake side and at the outlet. Both fans are expected to run when a large airflow rate is needed, for example for free cooling in summer. In a typical winter scenario, only the supply-side fan is expected to run, and at partial speed. The outside air is led through a 15 m long underground duct before it enters the building. That way, the daily temperature swings of the outside air are dampened, and the need for mechanical cooling is avoided.

**Components used to solve main issues or problems**

**IAQ control:** One CO$_2$ sensor located at about 1 m height in each room.

**Temperature control:** One temperature sensor located at about 1 m height in each room.

**Energy conservation:** Displacement ventilation diffusers, room outlet dampers for demand control and heat recovery from the building exhaust air.

**Ensuring low pressure drops:** Using large cross-section of ventilation ducts and by using large components for air handling.

**Control of air flow rate:** CO$_2$ sensors and temperature sensors to control outlet dampers for each room and supply- and exhaust fan for the building.

**Outdoor air pollution:** using the intake duct to settle large particles and a subsequent fine-filter (EU7) in the intake airflow.

**Draught** is avoided as a problem by using low-velocity and low-level diffusers in rooms and by using panel heaters below windows.

**Acoustic privacy** is ensured by using acoustic ceiling and wall panels in each room, by using specially designed air supply ducts installed in the basement distribution duct and by avoiding direct transmission of noise from the outlet damper of one room to another.

**Fire regulations:** The amount of combustible material in the intake air duct is kept very low. As long as the control system (BEMS) works, the CO$_2$ detection and the ventilation system will automatically work as an active smoke-control system.

**Maintenance** is partly carried out and supervised by the school caretaker. Mainly dry cleaning methods are used.
Control Strategies

When the building is unoccupied the ventilation airflow rate is low. As people enter a room, heat and CO$_2$ is emitted from the occupants and to the upper part of the room. A horizontal layer of air with a high CO$_2$-level grows downward and exposes, after some time, the CO$_2$ sensor that is connected to the BEMS. When the CO$_2$ concentration reaches a preset level, the BEMS signals the outlet air damper of the room to open one step at a time. If the damper is fully opened, and the CO$_2$ level at the sensor still is too high, the BEMS signals the fans to increase the speed. The supply and exhaust fans are also regulated in steps, and the two fans are controlled to each other to ensure that rooms are not pressurized compared to the outside at winter conditions. A similar strategy, as used for CO$_2$ control, is also used for temperature control.

The BEMS is a centralized system. An irregular value from a sensor is investigated by the school caretaker and with assistance from experts. Occupants may check indoor climate at a thermometer and at a display on the CO$_2$ sensor.

Overall performance

The BEMS strategy must be fine-tuned after one year of measurements and analysis of the data. With that task completed, and with the basis for design still valid, the annual energy consumption for the building is expected to be around 50,000 kWh. That value includes heating of space and of ventilation air plus electricity consumption.