A ventilative cooling system in a School Building, Imola, Italy

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A ventilative cooling system in a School Building, Imola, Italy

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Brussels, March 19-20, 2013
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Estimate of energy needs

PRELIMINARY - PHASE 1
- Focused simulations of energy strategies and comparison to a benchmark configuration
- Calculation of annual energy needs using simplified tools

Attention to ventilation load
Need to high-performance glazing

Priority to application of passive cooling systems

Data related to the South-West block

SOLUTION D
To optimize yearly energy balance

TECHNOLOGICAL OPTIONS FOR INDOOR CLIMATE CONTROL SYSTEMS

Architecture

South view of the School Building

Data related to the South-West block for an occupation period from September to July

Data related to the North-West block

Attention to ventilation load
Need to high-performance glazing

Priority to application of passive cooling systems

South East longitudinal axis

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North view of the School Building

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**Ventilation system**

- Hybrid system (controlled natural/mechanical system)
- Controlled natural ventilation (CNV): motorised sensor-driven openings related to IAQ and thermal comfort

- Cafeteria and discontinuous-use spaces:
  - Winter - mechanical
  - Summer - mechanical

- Classrooms:
  - Atrium:
    - Winter - mechanical
    - Summer - mechanical + CNV
  - Winter - mechanical
  - Summer - mechanical + CNV

**Cooling systems**

- Absorption chiller
- Vacuum Solar Collectors on roof
- Radiant floor
- Ventilative Cooling systems

**Ventilative cooling**

- Natural stack-driven airflow through the south-facing class rooms and the atrium

**Ventilation**

- Isolated suspended-ceiling element integrating lighting, sound adsorption, and air diffusion

**Isolated suspended-ceiling element**

- Ventilative cooling: laboratory testing of air downdraft distribution

**Internal view**

- Ventilated clerestory on the atrium glazed roof

**South glazed wall**

- Ventilative cooling

**Internal view**

- Ventilated clerestory on the atrium glazed roof

**South glazed wall**

- Ventilative cooling
2-D CFD simulation in a classroom with ceiling appliances:
- Air temperature zones after 1 hour with a gradient of 10 °C

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2-D CFD simulations: enthalpic flows for the three storeys in the time interval 0-400 s

Unbalanced flows amid the three storeys

Balanced flows amid the three storeys

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3-D CFD simulations: airflow rate and enthalpic flow in the time interval 0-6500 s (linear trend)

500 2500 4500 6500

3-D CFD simulations: airflow rates, enthalpic flow and global thermal exchange coefficient in the time interval 0-850 s

3-D airflow rate, 2-D airflow rate, 3-D enthalpic flow
global thermal exchange coefficient for floor, ceiling, walls

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Night cooling of thermal mass

3D CFD simulation of flow between a classroom and the atrium: temperature zones for a gradient of 10°C between inside (atrium) and outside

after 5 minutes

after 35 minutes

after 1 hour

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Thermal dynamic simulations using TRNSYS: annual indoor air temperature profile in the south-facing classrooms with ventilative cooling

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Thermal dynamic simulations using TRNSYS: annual indoor air temperature profile in the 3rd-storey south-facing classroom.

- Ambient (blue): indoor without VC (pink); indoor with VC (green).

**Contribution to energy saving of RES & RUE technologies (prediction)**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Annual energy intensity (kWh/m²-gfa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference configuration (a)</td>
<td>Heating: 28.8  Cooling: 64.4</td>
</tr>
<tr>
<td>High insulation (opaque components)</td>
<td>Heating: 30.3  Cooling: 66.4</td>
</tr>
<tr>
<td>High insulation (glazed components)</td>
<td>Heating: 28.4  Cooling: 64.3</td>
</tr>
<tr>
<td>Time optimisation of mechanical ventilation (OMV)</td>
<td>Heating: 10.8  Cooling: 10.8</td>
</tr>
<tr>
<td>Shading devices (fixed)</td>
<td>Heating: 14.0  Cooling: 14.0</td>
</tr>
<tr>
<td>Shading devices (fixed and movable)</td>
<td>Heating: 14.1  Cooling: 14.1</td>
</tr>
<tr>
<td>ET + OMV + heat recovery</td>
<td>Heating: 20.1  Cooling: 67.0</td>
</tr>
<tr>
<td>High insulation (opaque components)</td>
<td>Heating: 14.0  Cooling: 14.0</td>
</tr>
<tr>
<td>ET + OMV + Solarwall®</td>
<td>Heating: 13.0  Cooling: 13.0</td>
</tr>
<tr>
<td>ET + OMV + VC (green)</td>
<td>Heating: 9.8   Cooling: 9.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>Heating: 66.8  Cooling: 66.8</td>
</tr>
</tbody>
</table>

*U* value (walls): 0.45 W/m²K; *U* value (glazing): 2.65 W/m²K

Additional configurations:
- Mech. Vent. for 12 h/day
- Mech. Vent. for 24 h/day

Annual energy intensity:
- Heating: 179500 kWh/year
- Cooling: 443000 kWh/year

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