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

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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

Data related to the South-West block:
Priority to application of passive cooling systems

SOLUTION D to optimise yearly energy balance

Estimate of energy needs

PRELIMINARY - PHASE 2
Evaluation of energy-saving benefit related to alternative strategies

Calculation of annual energy needs using simplified tools

Architecture
International Workshop: Ventilative Cooling
Need, Challenges and Solution Examples

Ventilation system

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

Spaces:
- Cafeteria and discontinuous-use spaces:
  - Winter - mechanical
  - Summer - mechanical
- Atrium:
  - Winter - mechanical
  - Summer - mechanical (+ CNV)

Controlled natural ventilation (CNV): motorised sensor-driven openings related to IAQ and thermal comfort

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Cooling systems

- Mechanical ventilation
- Absorption chiller
- Vacuum Solar Collectors on roof
- Radiant floor

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Ventilative cooling

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

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Ventilative cooling

- South glazed wall with hopper window openings

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

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Isolated suspended-ceiling element integrating lighting, sound adsorption, and air diffusion: laboratory testing of air downdraft distribution

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

2-D CFD simulation in a classroom with ceiling appliances:
air velocity zones after 1 hour with a gradient of 10 °C

2-D CFD simulation in a classroom with ceiling appliances:
air velocity contour lines after 1 hour

2-D CFD simulation in a classroom with ceiling appliances:
radiation heat flux after 1 h as a function of distance from inlet opening

2-D CFD simulation in a classroom with ceiling appliances:
total surface heat flux after 1 h as a function of distance from inlet opening

2D CFD simulation of flows between classrooms at the different storeys and the atrium: temperature zones for a gradient of 10 °C between inside (atrium) and outside
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 simulation of flow between a classroom
and the atrium: temperature zones for a gradient of 
10° C between inside (atrium) and outside

Night cooling of thermal mass
after 5 minutes
after 35 minutes

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

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3-D CFD simulations: airflow rate and enthalpic flow in 
the time interval 500-6500 s (linear trend)

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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.

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>79.0</td>
</tr>
<tr>
<td>Reference configuration (b)</td>
<td>120.9</td>
</tr>
<tr>
<td>High insulation: opaque components</td>
<td>79.7</td>
</tr>
<tr>
<td>High insulation: glazed components</td>
<td>96.0</td>
</tr>
<tr>
<td>Time optimisation of mechanical ventilation (OMV)</td>
<td>69.9</td>
</tr>
<tr>
<td>Shading devices (fixed)</td>
<td>86.6</td>
</tr>
<tr>
<td>Shading devices (fixed and movable)</td>
<td>14.0</td>
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<tr>
<td>Total of envelope technologies (ET)</td>
<td>87.0</td>
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<tr>
<td>ET + OMV + heat recovery</td>
<td>81.3</td>
</tr>
<tr>
<td>ET + OMV + Solarwall®</td>
<td>88.0</td>
</tr>
<tr>
<td>ET, OMV, + VC</td>
<td>88.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>88.0</td>
</tr>
</tbody>
</table>

Reference configuration (a) cooling with Mech. Vent. for 12 h/day.
Reference configuration (b) cooling with Mech. Vent. for 24 h/day.

Annual energy intensity [kWh/m²-gfa]:

- Mechanical Ventilation for 12 h/day: 67.0 kWh/year
- Mechanical Ventilation for 24 h/day: 67.0 kWh/year

179500 kWh/year

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