Natural ventilation at Vridsløselille School, Albertslund, Denmark

DK3

1 Photo

Figure1: Vridsløselille School façade

2 Project summary

In part of the thorough renovation of Vridsløselille School, the local authority wanted to use natural ventilation. Cenergia, in co-operation with the other consultants, designed the natural ventilation system. It was based on the firm's previous experience with two projects: the renovation of Egebjerg school in Ballerup, and the erection of Stege School.
The task at Vridsløselille School was to replace the existing ventilation system with alternative ventilation, which, due to building changes, was necessary in order to secure a satisfactory indoor climate with regards to health. It was expected that a renovation of the ventilation scheme would result in an improved indoor climate; as well as lower running costs.

3 Site

Albertslund near Copenhagen, Denmark, latitude: 56.5°N., longitude: 8.5°E, Altitude: 10 m. Temperate coastal climate. Mean annual temperature: 8°C, mean winter temperature: 4°C.

4 Building description /typology

4.1 Typology / Age

Typology/Age	Pre 1910	1910–1930	1930–1950	1950–1970	1970–
The central corridor school					●
The cluster school					●

Educational level (kindergarten, pre-school, ...): SFO + Pre-school, primary and secondary school, plus rooms for keeping younger children outside school hours.

4.2 General information

Year of construction: 1968
Year of renovation (as described here): 2000
Total floor area (m^2): 1740 m^2
Number of pupils: max 200
Number of classrooms: 10
Typical class room
size: 74 m^2
window/glass areas: 23,1 m^2
number of pupils: 20–25
Hours of operation (specify, eg,: 1/1,_, _th of building): 8 (1/1)

4.3 Architectural drawings

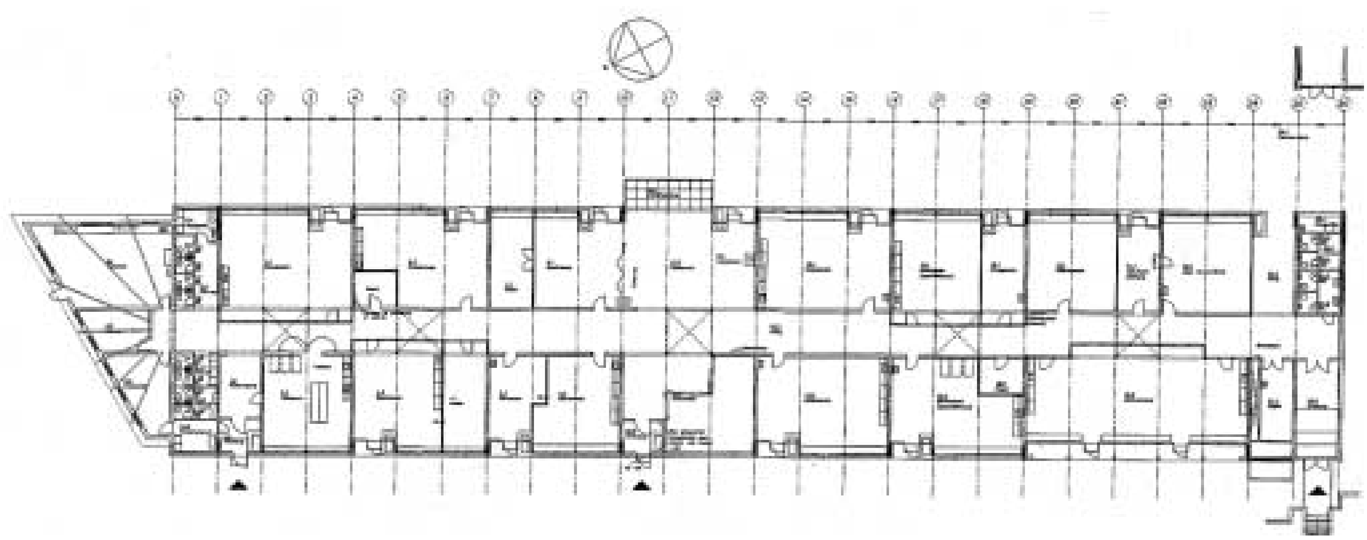

Figure 2: Floor plan.

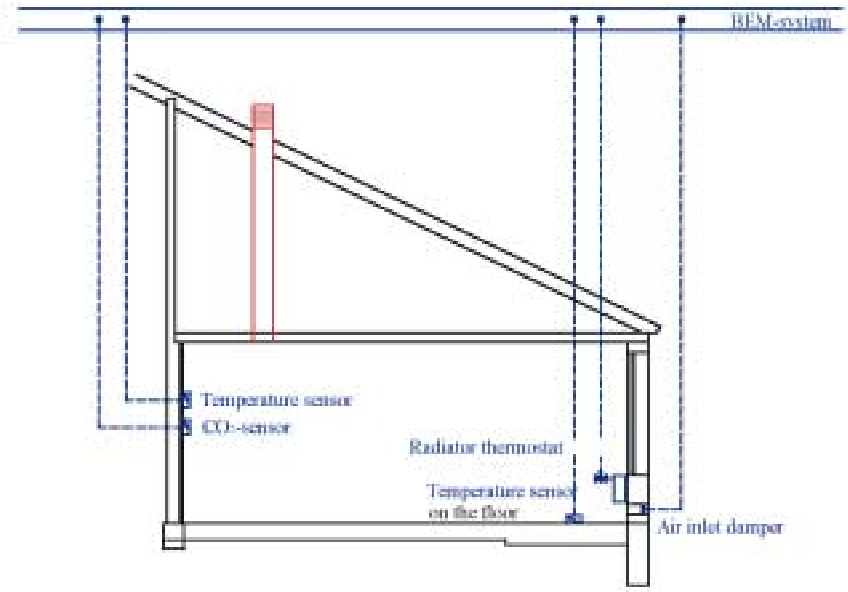

Figure 3: Technical section.

5 Previous heating, ventilation, cooling and lighting systems

From the beginning the school had a mechanical ventilation system with supply and exhaust air and some recirculation. The ventilation system did not have heat recovery. Heating coils were installed in the supply ducts for preheating the supply air. The ventilation system was not operating very well, because of lack of maintenance, which resulted in poor indoor air quality together with high energy consumption for space heating.
The building was heated partly by a ventilation system and partly by radiators. There was no cooling system installed.

6 Retrofit energy saving features

6.1 Energy saving concept

100mm extra insulation on roof.
The natural ventilation would reduce heat losses due to improved ventilation control.

6.2 Building

The building envelope has only been improved with 100mm additional insulation on the roof. Daylight conditions have been improved considerably due to the addition of more dome lights in the corridors. The old classrooms have also been divided so an improved room division has been obtained, making allowances for the new requirements of education in the school of today.

6.3 Heating

New radiators are installed to cover the transmission and ventilation losses. The ventilation air is preheated by passing through a new type of boxing encasing the radiators - located below the windows. The radiators are automatically controlled in each room by the BEMS. During the night and in unoccupied periods the room temperature is lowered.

6.4 Ventilation

The ventilation principle is natural ventilation without any fans. The air intake is through the facade below the windows and the outlet is through a duct passing through the attic to the roof. The fresh air is preheated by a radiator before it enters into the room. An air inlet damper is installed and controlled by the BEMS depending on the indoor air quality in the classroom. The air quality is monitored individually in each classroom by a temperature and a CO_2 sensor. The natural ventilation system did not include heat recovery, active cooling nor a dehumidification system.

Comfort cooling: No
Dehumidification: No
Pre-heating of ventilation air: Yes, by radiators
Heat recovery: No
Controls: Yes, by BEMS
Other features: Weather stripping, draft exclusion, draft lobbies

7 Resulting Energy Savings

Estimated by computer simulation using the Comis program.
Energy consumption before and after:
Heating: Lower transmission losses – 31000 kWh = 17.8 kWh/m^2
Cooling: No cooling
Before new ventilation system: 45000 kWh heating and 10500 kWh electricity
After new ventilation system: 17000 kWh heating and 0 kWh electricity
Estimated total savings: 33.9 kWh/m^2 heating and 6 kWh/m^2 electricity
Lighting: unknown

8 User evaluation

The indoor air quality has not been evaluated by questionnaires. Only the ventilation flow rate and the CO_2 level have been monitored. The CO_2 level has been monitored in one classroom during a cold winter period and the results are shown in the figure below. When the classroom is occupied the maximum CO_2 level is between 1000 and 1500 ppm. By tracer gas the air tightness was measured as 0.7 ach^{-1} with closed dampers and 1.5 ach^{-1} with dampers open.

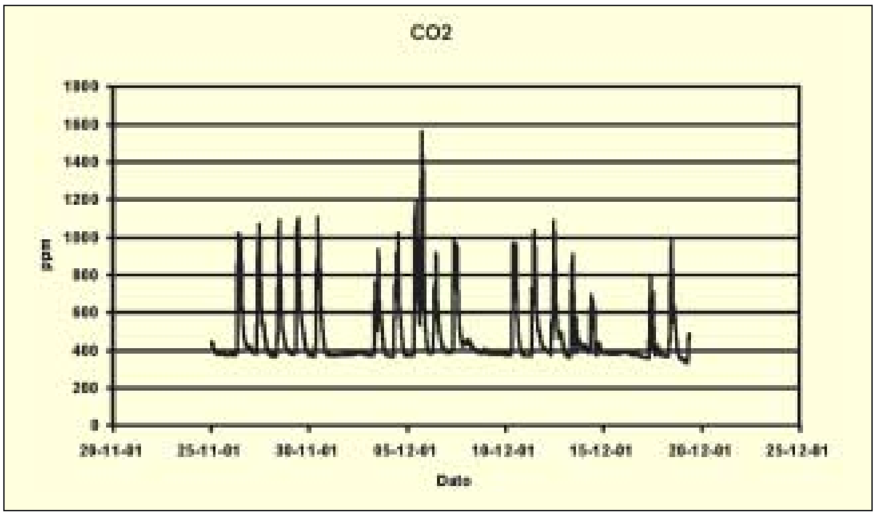

Figure 4: CO_2 levels in a classroom during a winter period.

Quality of daylight / artificial light: The daylight quality has not been evaluated but the general feeling of the daylight is good and it has improved a lot.

Sound quality: no evaluation

General feeling: no evaluation
General well being: no evaluation
Headache: no evaluation
Difficult to concentrate: no evaluation

Technical functionality (are the technical solutions easy or difficult to operate?). The technical installations don't need any operation by the user.

Architectural quality: no evaluation

9 Renovation costs

Specific cost per technology (as specific as possible):
Renovation costs: 12.447.500 DKK (€1.671.000) excl. VAT
Implementing natural ventilation: 1.650.000,- DKK (€221.500) excl. VAT.

10 Experiences/Lessons learned

10.1 Energy use

The predicted yearly energy use before the renovation was 345 MWh equating to 194 kWh/m^2. The ventilation losses were 45 MWh (25 kWh/m^2).
The predicted energy saving for ventilation is 28.3 MWh (16 kWh/m^2).
The predicted electricity saving by introducing natural ventilation is 10.5 MWh per year (6 kWh/m^2).
The monitored energy consumption for heating after the renovation is not available.

10.2 Impact on indoor climate

Thermal: Improved
IAQ: Improved
Drafts: No complaints

10.3 Economics

There were two options for the renovation:
Renovation of existing ventilation system and new radiators: DKr 1,200,000.-
Natural ventilation and new radiators including control: DKr 1,600,000.-

10.4 Practical experiences of interest for a broader audience

Natural ventilation with automatic operation of the air inlet dampers. The opening of the air inlet dampers depends upon the indoor temperature and the concentration of the CO_2.
New window design that integrates the air inlet with solar preheating of the ventilation air.

10.5 Resulting design guidance

Daylight:
Good results were achieved from the following measures:

- Increased floor to ceiling height of the corridors
- Installation of new roof glazing, painting surfaces in light colours
- Additional partially glazed partition walls were added between classrooms increasing the amount of daylight.

Ventilation:
When an old mechanical ventilation system has to be removed and replaced by natural ventilation, it is important to minimise the risk of draught by using a combination of dampers placed under the windows in the facade of the building, supplemented with air inlets through high level motor controlled windows in the facade. The control should be designed as a combination of automatic and manual control.

Control:
Heating and ventilation is best controlled with a simple automatic control combined with a manual user control.

11 General data

11.1 Address of project

Vridsløselille Skole
Nyvej 5
2620 Albertslund

11.2 Existing or new case study

Project initiation:	15/1/1999
Design completed:	10/12/1999
Renovation construction completed:	1/9/2000
Monitoring and evaluation completed:	15/12/2001

11.3 Date of report / revision no.

August 2002/3.

12 Acknowledgements

Builder, architect, engineer, national, international support programmes.

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