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Kampen School, Norway.

A demonstration project where new concepts for energy efficient ventilation and lighting are integrated

1 Photo

Figure 1: Kampen school facade.

2 Project summary

The objectives of the project were to:

- Demonstrate that schools can be retrofitted with hybrid ventilation and provide a comfortable indoor climate.
- Improve control of glare and thermal radiation without decreasing the daylight factor. Use of natural daylight will also reduce energy demand for lighting.
- Demonstrate the importance of using optimal light sources for indoor climate and energy needs.
- Demonstrate with Life Cycle Cost (LCC) analysis that these solutions mean good economy for the building owners.
- Demonstrate that these solutions work in a city environment.
- Evaluate the connection between indoor climate and human efficiency and optimise the ventilation and lighting in accordance with this.
- Demonstrate demand controlled ventilation and lighting.

The project covered planning, implementation and evaluation of energy efficient concepts. The planning and engineering studies started during the year 2000 and the whole building will be finished in summer 2003.

3 Site

Kampen School is located in a typical city environment in Oslo. Mean annual temperature is about 6° Celsius and winter temperature can be as low as –20° Celsius.

Latitude: 60° N, longitude; 11° E

4 Building description /typology

4.1 Typology / Age

Typology/Age	Pre 1910	1910-1930	1930-1950	1950-1970	1970-
The pavilion school	●				

Kampen School is a school for pupils from 6 to 12 years with a possibility for 28 pupils in each class.

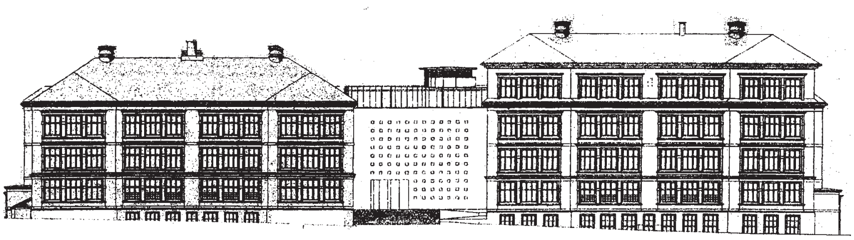
4.2 General information

Year of construction: 1888
Year of renovation: 2001 and 2002
Total floor area (m^2): 4500
Number of pupils: About 400
Number of classrooms: 30
Typical classroom :
size : 65m^2
window/glass areas : 15m^2
number of pupils: up to 28

4.3 Architectural drawings

Figure 2: The existing east facade of Kampen school.

Below: The new west facade of Kampen school.



Kampen School originally consisted of two separate buildings. These two buildings have been joined together by a new building that contains new, necessary accomodation including a media room and library. The project has also focused on ease of maintenance. The concrete duct which transports air from the intake ventilation tower to the verticals shafts, is easily accessible for maintenance with sufficient height for walking upright and with white walls and lighting.

5 Previous heating, ventilation, cooling and lighting systems

5.1 Heating system
A conventional hot water radiator heating system with manual thermostatic valves provided perimeter heating in winter. The existing heating capacity of 1.040 kW proved to be insufficient. This may have been due to malfunctioning of the system. The peak heating effect is calculated as 1.090 kW.
Two oil boilers and one electric boiler were available, but the electric boiler was malfunctioning and one of the oil boilers had a leak.

5.2 Ventilation system
The mechanically balanced ventilation system provided each classroom with approximately 120 litre/second of fresh air. This proved to be insufficient to create a good learning and teaching environment. The Norwegian Building Code recommends about twice as much fresh air per classroom.

5.3 Cooling system
There was no cooling system.

5.4 Lighting system
The old lighting system had nine 2x65 W luminaires mounted on the ceiling, with manual on/off switches. There was no blackboard lighting.

6 Retrofit energy saving features

6.1 Energy saving concept
The calculated energy savings are due to:
- Improved control of radiator heating because of new thermostatic valves
- Reduced fan power energy because of optimal use of natural driving forces
- Demand controlled ventilation with heat recovery
- Demand controlled artificial lighting which means maximum use of daylight and minimum use of artificial lighting

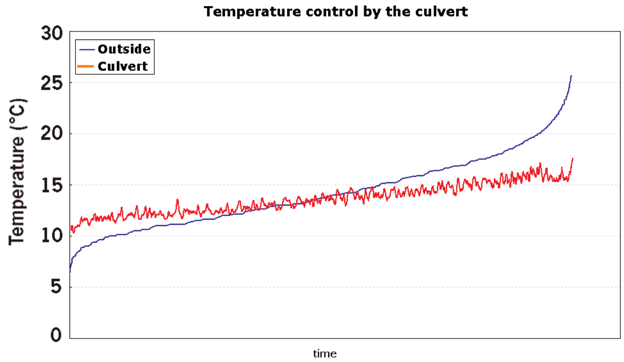
6.2 Building
Kampen School was retrofitted in 1978 and the windows were changed in 1998/1999. The exterior, including cladding, insulation and windows, will be kept unchanged during this retrofitting because it is considered of sufficient quality. This is the most environmentally favourable solution.

6.3 Heating
New hot water radiators with thermostatic valves will provide perimeter heating in winter with improved energy control and thereby reduced use of energy. Two new oil boilers and one electric boiler with a total of 1.200 kW will be installed; the type of boiler use will depend on spot energy price. Use of a ground-water heat pump will be evaluated during the construction period.

6.4 Ventilation
The school will be ventilated with fan assisted natural ventilation, or hybrid ventilation. The ventilation solution will be based on the original building integrated ventilation solution from 1888. This solution had air intake at each end of the building. Because of traffic pollution, there will be a new air intake on the top of the new connection building. The air will pass through a filter and a run-around heat recovery battery with low pressure drop, then pass via a concrete duct, under the building, finally toward separate vertical shafts to each classroom.
The thermal mass in the intake tower, concrete duct and vertical shafts will

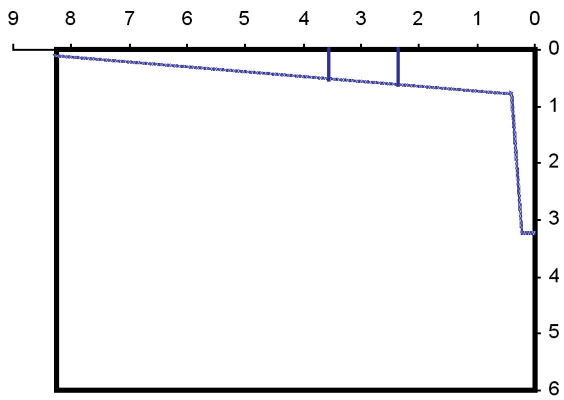
provide a considerable amount of cooling on hot days because they are cooled down at night during the hot period of the year by means of night-ventilation.

Table 1: The figure shows temperature outside and temperature after the culvert during the hot period of the year for Jaer School in Norway. As one can see the culvert has a considerable cooling effect on fresh air.



The rooms will be ventilated with displacement ventilation through an integrated wall that will ensure no conflict between ventilation function, draft and the use of the rooms. The inlet for supply air is placed behind the new wall. A shelf under the air inlet is designed to spread the air equally along the long side of the classroom. The air is then distributed to the room through a perforated zone in the lowest metre height of the wall.

Table 2: Plan of an original classroom and the new inner wall. *Measurements in metres.*



During normal conditions, the classroom has a considerable heating load. It is a challenge to ventilate for this heating load without getting problems with drafts. A laboratory study indicated that the supply air temperature will increase about 2°C from the inlet behind the integrated wall to the air inlet in the room. This means that the new integrated wall will serve as a cooling panel, making it possible to add some extra cooling to the ventilation air. The new integrated wall will also serve as an acoustic dampener for the room.

The exhaust air will pass through a heat recovery battery.

Demand controlled ventilation will be used. The control system is a supervisory control (BEMS). In principle, operation is by a centralised system. The type of management is internal by caretaker, or remote via a modem.

Ventilation demand in the classroom is controlled by indoor temperature during the hot period of the year (outdoor temperature above 13°C), and by the

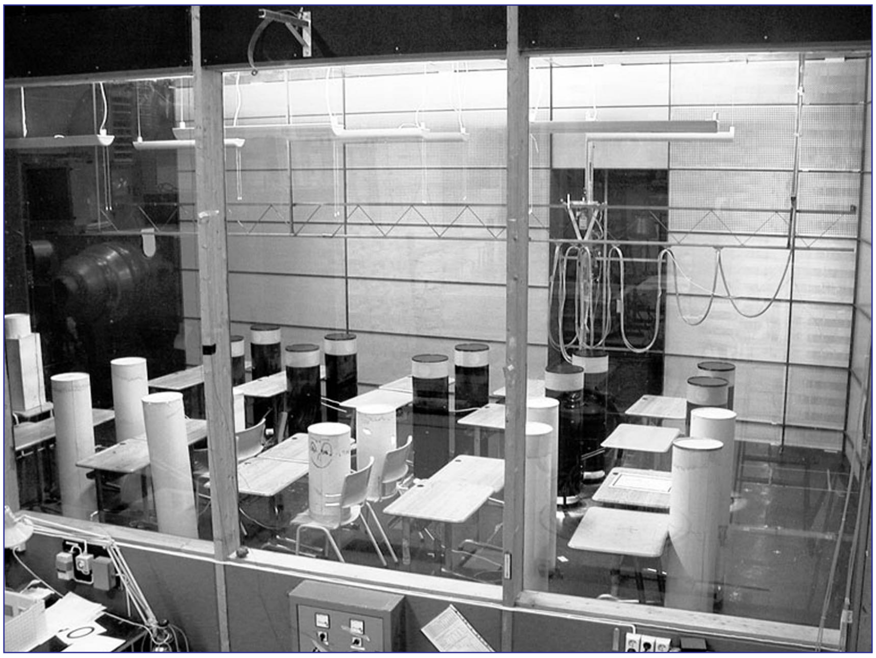


Figure 3: A laboratory study has been conducted. One can see the new inner walls.

production of CO_2 during the cold period of the year. Airflow to each classroom is controlled by motorised blade dampers which are all located in the culvert for easy access for maintenance. When the CO_2 level or the temperature in the room rises above the set-point values 900 ppm or 22°C, the damper opens up. If the CO_2 or temperature increases further up to 1000 ppm or 24°C, the exhaust fan gradually speeds up.

6.5 Lighting

Use of daylight in classrooms

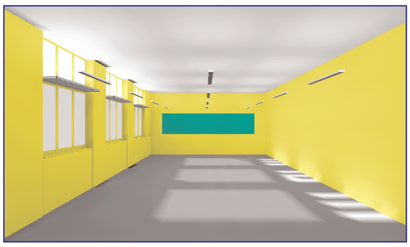
The windows in the classroom are 2.3m high, from 1.2m to 3.5m above the floor. The room is 3.6m high. The windows are split in two with a 0.5m deep shelf placed 2m above the floor, as seen in Figure 5. The top of the shelf is a dim white colour. Most of the sunlight coming through the window above the shelf will be reflected on to the ceiling and give light to the room. That means all the sunlight above the shelf cannot cause glare in the classroom. Glare from the sun below the shelf is handled by use of curtains. When all curtains are in use, the daylight factor is about 1% on average.

It is also possible to black out the windows above the shelf.

Figure 5: Daylight control

a. The classroom without shelves or curtains

b. The classroom with shelves.



c. The classroom with shelves and curtains.

Use of artificial lighting in classrooms
A manual switch and an Infra Red (IR) movement detector control the suspended pendant luminaires. In order to switch the lights on, it is necessary to use the switch, but the IR detector may turn off the lights if there is no movement in the room. In this case it is necessary to turn them on again by the manual switch. The idea is that the lights will only be turned on if daylight seems insufficient. This was the most cost effective way to exploit daylight. The system is simple, and the teachers and pupils have to manually switch on lights.

The blackboard lighting is switched on/off by a switch mounted close to the blackboard, which is used by the teacher.

The lighting system is based on suspended pendants 2x 36W with high frequency ballasts. The light distribution ratio is 70% upwards and 30% downwards. The blackboard is lit with three luminaires of 1x 36W.

Offices
The lighting system is based on fluorescent suspended pendants of 2x 36 W with high frequency ballasts.

6.6 Other environmental design elements
Low emission and environmentally favourable building materials and finishings will be used in order to decrease the pollution load as much as possible.

7 Resulting Energy Savings

Before refurbishment the temperature corrected energy consumption was measured to be 205 kWh/m^2, where 55 kWh/m^2 of the energy consumption was electricity used by fans, pumps, equipment and lighting, and an additional 150 kWh/m^2 was needed for heating. After refurbishment the energy consumption has been calculated to be 169 kWh/m^2 despite the fact that ventilation rates will be more than twice as high as those prior to

	Before	**After**	**% Reduction**
Local heating	92	77	17 %
Central heating	52	58	–11 %
Domestic hot water	6	5	17 %
Fans and pumps	24	6	75 %
Lighting	21	13	38 %
Equipment	10	10	0 %
Cooling	0	0	0 %
Total	**205**	**169**	**18 %**

Heating includes local heating, central heating and hot water. Below the energy consumption is divided into heating and electricity.

	Before	**After**	**% Reduction**
Heating	150	140	7 %
Fans, pumps, lighting and equipment	55	29	47 %

In addition to the above the new system will contribute to a significant amount of free cooling.

refurbishment. Some of the heating energy is provided by electricity, which is quite common in Norway.

8 Renovation costs

The total renovation cost is estimated to be €11.000.000. The part of this cost that is affected by the new ventilation system is calculated to be about €840.000. Traditional mechanical ventilation would cost approximately €780.000. Despite the higher investment cost, the alternative with hybrid ventilation has the lowest annual cost of €12,5/m^2 compared to traditional mechanical ventilation with an annual cost of €15,5/m^2, producing much lower life cycle costs.

9 Experiences/Lessons learned

Refurbishment completion date is summer 2003.
The school will be in use from autumn 2003.

10 General data

10.1 Address of project
Kampen School, Normanns. gt. 57 A, Oslo.

11 Acknowledgements

Builder:	Community of Oslo – school administration
Architect:	Richard Engelbrektson
HVAC engineer:	Bakke, Søderblom og Tønsberg A/S
Electrical engineer:	Nielsen & Borge A/S
Special adviser ventilation and lighting:	Norwegian Building Research Institute
Author:	*Mads Mysen, Norwegian Building Research Institute.*

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