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School sets good example on retrofitting

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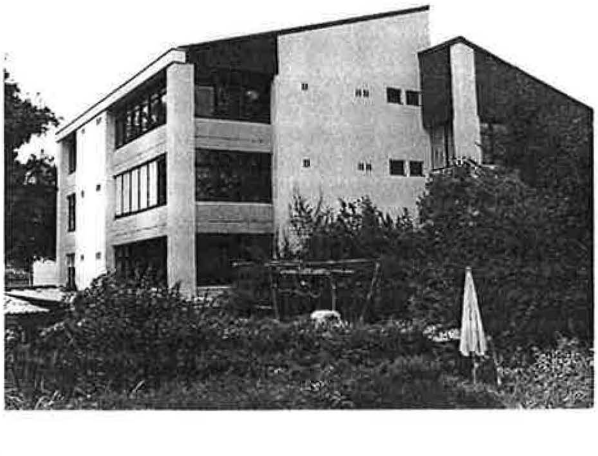
Grüningen primary school near Zurich, Switzerland, was built 20 years ago, and energy consumption, in particular for heating and lighting, was unnecessarily high. An unconventional retrofitting procedure involving new chip-wood furnace, interior insulation, mass-coupled ventilation and controlled artificial lighting was adopted. The work was carried out without interruption of normal school operation. The results are very promising and measurements indicate a drop in heat consumption of 70% with standards of comfort raised considerably. Incurred costs proved quite reasonable compared to those of other retrofitting techniques.

Introduction

The objective of the retrofitting was to reduce energy consumption and raise the standard of comfort by improvements to ventilation and lighting. The work had to be carried out without interrupting school operation. Typical of primary schools are the short occupation periods, the school being effectively in use only for about 18% of the time (not counting holidays, weekends and nights). To satisfy the clean air regulations it was necessary to replace the oil-fired boilers. Repairs to the building fabric and general maintenance work were also necessary.



External view of retrofitted school building.

Advantages of interior insulation

In addition to the interior insulation finally adopted, a conventional retrofitting procedure involving exterior insulation was first studied. However this was rejected for the following reasons:

- external insulation is more expensive because of the need to protect it from the weather;
- the thickness of exterior insulation must be greater than for interior insulation owing to the larger and more complicated external surface and is thus more expensive;
- a lower nighttime temperature is less effective with exterior insulation;
- the architectural features of the building are affected;
- the retrofitting could not have been carried out in stages, as normal school operation would have had to be interrupted.

In the case of interior insulation, all interior surfaces of the main construction parts of the building (including walls, floors and ceilings) must be moderately insulated. To quantify the effects of this, simulation studies were carried out.

In the simulations, particular attention was paid to the question of temperature control. A timer was used to reduce temperatures when the building was not in use (i.e. during holidays, weekends and at night). The results showed that in rooms with only short periods of occupation, a lower temperature saves 10% of heating energy at practically no additional cost. The reason for this is that with interior insulation, the air in the room is thermally decoupled from the building mass, so that its temperature may be considerably reduced. This is not possible with exterior insulation owing to the thermal inertia of the building. The additional cost of providing internal insulation is quite low since retrofitting buildings almost invariably involves redecorating the interior surfaces.

The energy design concept adopted may also be applied to other buildings with short periods of occupation, e.g. conference rooms, weekend chalets and buildings under heritage protection laws, where no changes to the façades are permitted.

Realisation

Internal insulation was applied at Grüningen school as shown in **Table 1**.

Component	Internal insulation	Thickness	Remarks
Floor resurfacing	Cork parquet	8 mm	Floor needed
External walls and window recesses	Rock wool with vapour barrier	5-8 cm	
Interior walls	Cork linoleum	6 mm	
Ceilings	Wood-wool board	25 mm	Improved room acoustics as useful side-effect
Cellar roof and top floor ceiling	Expanded polyurethane (applied externally)	20 cm	External insulation used to avoid encroachment on room space

Table 1: Insulation of internal surfaces at Grüningen primary school.

With interior insulation, precautions are necessary to prevent overheating in summer, and correct operation of the sun blinds is critical.

Each classroom is provided with a separate ventilation system with heat recuperation, see **Figure 1**. In winter, heat from the exhaust air is transferred to the incoming air by means of a cross-flow plate heat exchanger. In summer, outdoor air is cooled by passing it through the concrete slab, the slab itself being cooled by outdoor air during the night. The ventilation is switched on and off by a occupancy sensor. Following monitoring, results show that temperatures during the summer months remained within acceptable temperature parameters.

After preheating in the plate heat exchanger, the outdoor air passes into the space between the concrete slab and the acoustic baffle, where its temperature is further raised. Air is distributed in the room using the principle of natural convection. The air supply rate is 15 m^3/h per person or max. 360 m^3/h.

Central heating is provided by a chip-wood furnace coupled to a 10 m^3 heat storage tank with integral hot water tank. In summer, domestic hot water is provided by an electrical air-to-water heat pump.

The artificial lighting was optimised using light and occupancy sensors connected to a simple controller. Finally, the windows were weather-stripped and fitted with selective glazing.

A measurement project is now in progress to obtain detailed information on energy consumption and standard of comfort. Both the retrofitting and the measurement projects enjoy the technical and financial support of the County of Zurich and the Federal Government.

Results

The costs of retrofitting amounted to approximately CHF 90,000 per classroom. Energy related costs were estimated at CHF 30,000, resulting in an actual energy saving of 814 litres of oil per year per classroom. To achieve the same result with conventional techniques based on exterior insulation would have cost 30-50% more. The energy-saving measures accounted for approximately 1/3 of total costs. The remaining 2/3 were for fabric maintenance and improvements to the standard of comfort.

Following the retrofitting, consumption of heating energy for the classrooms was down by approximately 70%. This is equivalent to a reduction of approximately 1,600 kg of heating oil from 2,200 kg to 600 kg per classroom. For the new plant, annual fuel consumption is approximately 6 m^3 of chip-wood per classroom.

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(see back cover).

Figure 1: Ventilation diagram.

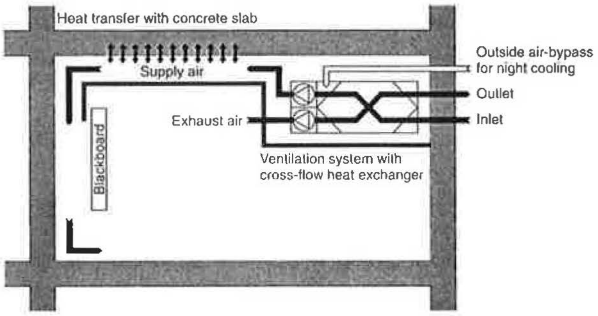

Table 2: Technical data.

Technical data	
Retrofitting period	1993-1994
Height above sea level	492 m
Number of classrooms	10
Heated floor area	1,170 m^2
Heated volume	5,900 m^3
Glazing U-value	0.9 W/m^2K
Capacity of chip-wood furnace (entire building)	130 kW
Ventilation capacity	10 x 360 m^3/h (15 m^3/pupil)
Lighting capacity	8.5 W/m^2
End Energy index before/after retrofitting	490/140 MJ/m^2a