Transparent insulations: applicability to the northern climate

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Transparent insulation materials and their applications are currently being studied at the Building Materials Laboratory of the Technical Research Centre of Finland (VTT). The aim of the study is to determine their applicability to a cold climate, and to find potential solutions. In the northern climate, active systems such as preheating of domestic hot water seem to be more usable than passive wall solutions. The annual heating energy consumption of small houses with a floor area of 125 m^2 was calculated. The consumption decreased by 10 - 25 % when 40 mm transparent insulation was added to south-, west- and east-facing walls.

1. Experimental building for wall systems

A number of applications based on transparent insulations were selected for an experimental building. The test wall is a south-facing, 70° inclined wall on the upper level of a two-storey building. The building was designed to study 2,5 m high test structures of variable width depending on the number of 1,2 m standard panels used. The overall width of the test wall is 16 m. The test structures are shown in Table 1.

Table 1. Test structures and applications.

1	lightweight concrete 250 mm closed air cavity 50 mm glass 6 mm capillary TIM 50 mm glass 6 mm	2	lightweight concrete 250 mm closed air cavity 50 mm glass 6 mm	3	lightweight concrete 250 mm closed air cavity 50 mm glass 6 mm white glasswool 50 mm glass 6 mm
4	lightweight concrete 250 mm white glasswool 50 mm glass 6 mm	6	hollow-core slab 160 mm closed air cavity 50 mm glass 6 mm capillary TIM 100 mm glass 6 mm	6	chipboard 12 mm mineral wool 50 mm hollow-core slab 160 mm closed air cavity 50 mm glass 6 mm
7	glass 6 mm capillary TIM 200 mm glass 6 mm	8	preheating of domestic hot-water integrated into a lightweight wall	9	dynamic wall as a solar collector

The results indicate that transparently insulated massive walls create a risk of overheating already in early spring if no shading or other restriction of radiation is provided. Temperatures on the black surface of light-weight concrete with 50 mm transparent capillary insulation (Table 1, structure 1) rose in April to as high as 140 °C causing damage to the capillary structure, Figure 1. Table 2 summarizes the energy flow for structures 1 - 4 in April 1991.

Table 2. Total and separate energy flow in the test structures 1 - 4 in April 1991. Heat flow measurements on the inner surface of the test wall.

Structure	Total Wh/m^2	In (-) Wh/m^2	Out (+) Wh/m^2
1	-4755	-4966	+211
2	+95	-1186	+1281
3	+2003	-3	+2000
4	+1820	-39	+1781

The test structure no. 7 is a well insulated daylighting wall. The main problem with a south-facing wall of this type is the occational high temperature on the inner surface (50 °C in April 1991), Figure 2.

2. Preheating of domestic hot water

In Finland,a family of four uses on average 200 - 250 litres per day of hot water. The estimated collector area in this case is 10 m^2. In the test set-up (Figure 3), the collector area is 1,6 m^2 and therefore the hot water use is adjusted to 40 l per day (20 l morning and evening). The measurements were started in March 1991. As shown in Figure 4, the water tank temperatures have slowly risen from the start of the test.

3. Energy analyses of low energy buildings

Twenty-three building designs were analyzed using calculations /1/. Table 3 summarizes the energy saving measures studied and results. The reference house met all of the U-value requirements currently in force in Finland. Nine of the 23 designs were insulated with transparent material in the south, east and west walls. The basic wall constructions in these buildings were massive sandwich structures or light-weight concrete structures with a U-value of 0,28 W/m^2K. The transparent insulation material was either 40 mm aerogel or capillary material (small capillaries). The estimated annual heating energy demand of the reference house was 20 MWh. Transparent insulation alone reduced this figure by 2 - 5 MWh. Combining the use of transparent insulations with other advanced techniques may considerably increase energy savings. Overheating, however, still proved to be a problem.

Table 3. Energy-saving measures studied and calculation results /1/.

IEA 3	IEA 2	IEA 1	25/8	25/7	25/6	25/1	50/9	50/8	50/7	50/5	50/2	50/1	75/12	75/11	75/10	75/9	75/8	75/7	75/6	75/5	75/2	75/1	HOUSE CONCEPT (CLASS/VERSION)
x	x	x	x	x	x	x		x	x	x		x										x	Improving thermal insulation
x	x	x		x	x	x	x	x	x	x	x	x	x	x						x	x	x	Improving thermal insulation of doors
			x		x	x	x	x	x		x	x		x						x		x	Window class 2 U = 1,2 W/m^2K
	x	x		x																			Window class 3 U = 0,6 W/m^2K
x																							Window class "super" U = 0,35 W/m^2K
	x		x							x													Window shutters
x	x	x	x	x	x	x			x														Tighter construction (leakage 0,1)
																	x	x	x				Small atrium (2 x 7 m)
																x							Large atrium (2 x 16 m)
															x								Three-sided atrium
	x		x		x	x	x				x		x	x						x			Transparent thermal insulation
							x	x	x	x	x	x					x				x		IV heat recovery e = 0,6 (ventilation)
x	x	x	x	x	x	x																	IV heat recovery e = 0,8 (ventilation)
17	17	17	21	23	24	24	55	52	44	50	62	47	72	81	78	82	74	84	89	80	80	75	Consumption compared with reference house (%)

4. Conclusions

The results from several studies indicate that in the Finnish climate the passive use of transparent insulation material on external wall is not the most efficient way of utilizing these materials. Active systems e.g. preheating of hot water prolong the efficient time of use for transparent insulations. Also, well insulated daylighting constructions are possible potential applications.

Reference:/1/ Kouhia, I. et al. Low Energy Residential Housing. Espoo Finland 1990. ETRR Research Program, Report 5. 22 + app. 38 p.

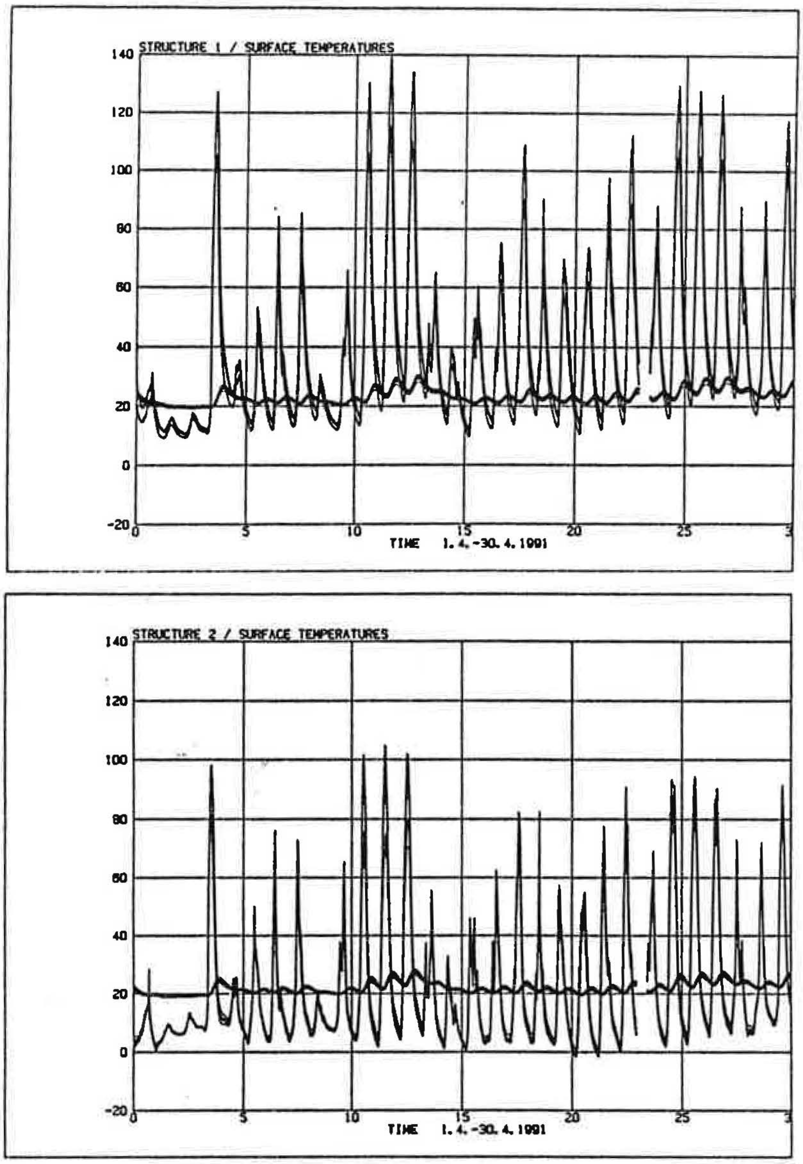

Figure 1. Test structures 1 and 2. Surface temperatures of the lightweight concrete in April 1991.

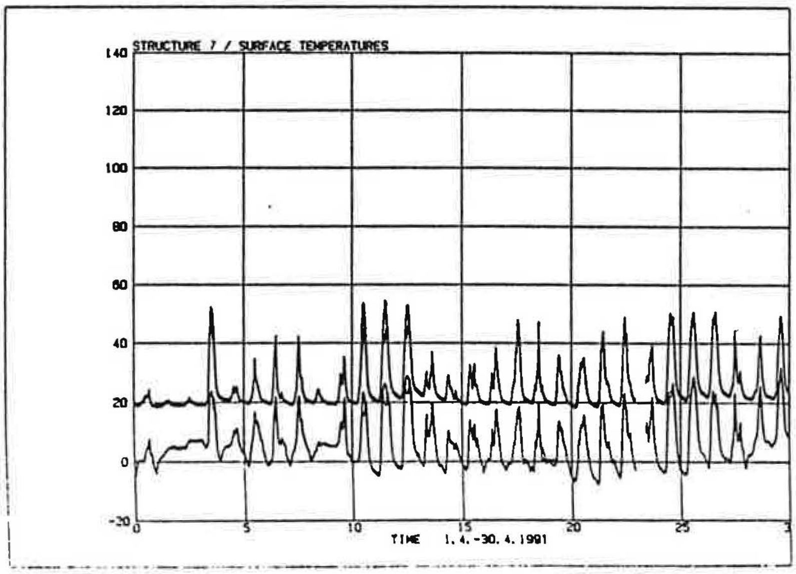

Figure 2. Test structure 7. Surface temperatures in April 1991.

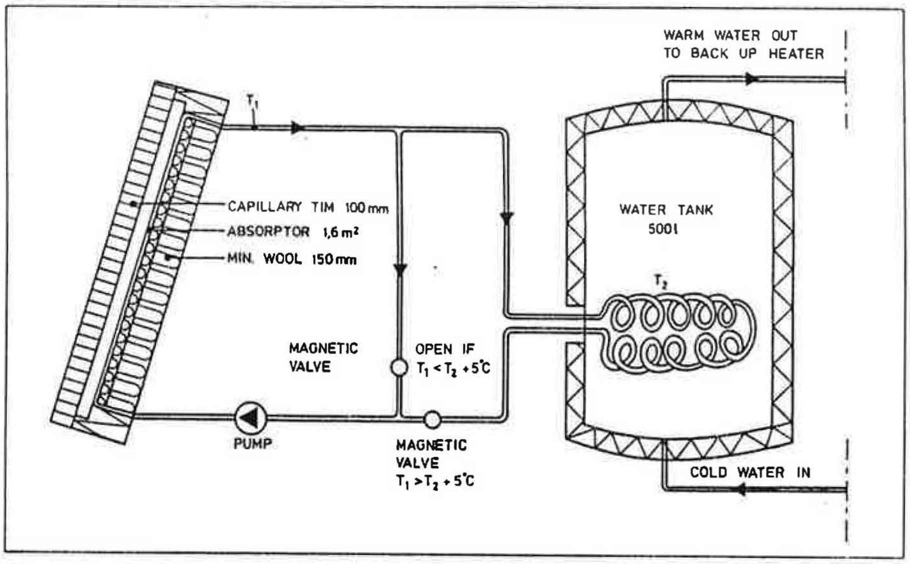

Figure 3. Domestic hot water heating system.

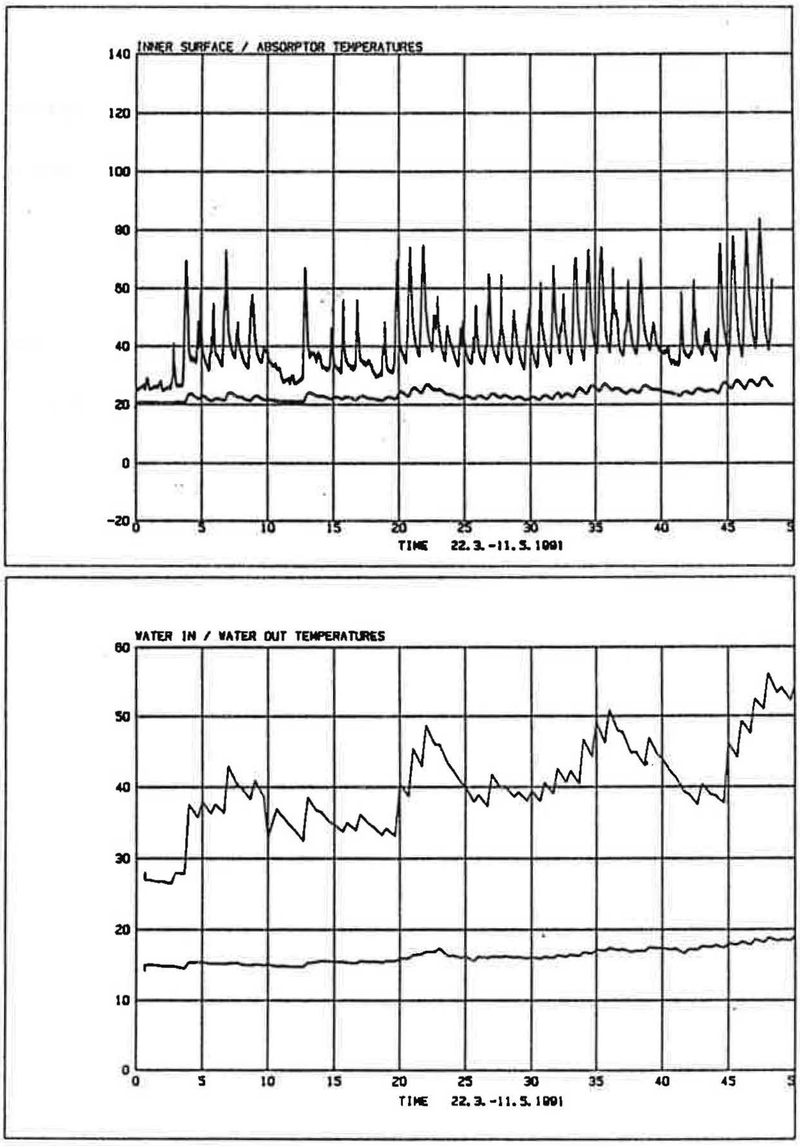

Figure 4. Hot water heating system. Temperatures on the absorption surface and inner surface of the wall. Water tank temperatures (preheated water to back up heater and supply water).