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Building Research Note

Thermal Environment in the Milbrandt Low-Energy House

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BRN 241

Canada

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BRN 241
ISSN 0701-5232
Ottawa, March 1986

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ABSTRACT

The Milbrandt low-energy house was built in 1980 in Saskatoon as part of a demonstration project. This paper discusses temperature distribution using point-source heaters as the sole heat source and relying on natural convection for distribution of heat. Summertime overheating in low-energy houses was also studied.

RÉSUMÉ

La maison à faible consommation d'énergie Milbrandt a été construite à Saskatoon, en 1980, dans le cadre d'un projet de démonstration. L'auteur de ce document étudie la répartition de la température dans une maison où n'existent que des sources de chaleur ponctuelles et où la chaleur n'est distribuée que par convection. Il se penche aussi sur le surchauffage des maisons à faible consommation d'énergie en été.

taped for some sets of measurements, and the chimney, combustion air inlet, and heat exchanger vents were blocked to force the interior temperature as high as possible.

RESULTS

Point-source Heating

Figures 1 and 2 show the temperature distribution throughout the house with all interior doors open, using only electric heaters as point heating sources. During the tests no air circulation was employed other than that from natural convection and small amounts from the fan-forced heaters. Figure 1 shows the temperature distribution during the heater-off cycle; Figure 2 shows it during the heater-on cycle. Figure 3 illustrates a similar test with all interior doors closed, giving the temperature distribution during the heater-on cycle. For all tests thermostatic control was from a central location on the outside of the curved wall separating the kitchen and living room.

Table 1 summarizes the three point-source heating tests, giving average temperatures for spaces open and not directly open to the heat source. During the open-door tests temperature variations throughout the house appeared to be minor, indicating minimal internal resistance to heat flow (natural convection and conduction and other forms of heat transfer). The maximum internal temperature difference was 12% of the total temperature difference between indoors and outdoors during the heater-off cycle. The warmest spot was in a dry-walled corner heated directly by electric resistance heaters. The coldest was in the lavatory off the master bedroom, the area farthest from heaters.

TABLE 1. Space Temperatures under Various Conditions, Electric Point-Source Heating

	Space directly connected to heat source			Space not directly connected to heat source			
	Kitchen/ dining	Living room	Hall	Master bedrm	Bedrm 2 (corner)	Bedrm 3	Basement
Doors open, heaters off $T_{ambient} = 0.2$ (Fig. 3)	21.8	22.0	20.8	20.0	20.4	20.9	18.9
Doors open, heaters on $T_{ambient} = -3.4$ (Fig. 4)	23.8	22.6	21.6	21.0	21.3	21.8	19.1
Doors closed, heaters on $T_{ambient} = 0.3$	22.9	21.4	21.0	17.0	16.0	17.9	17.1

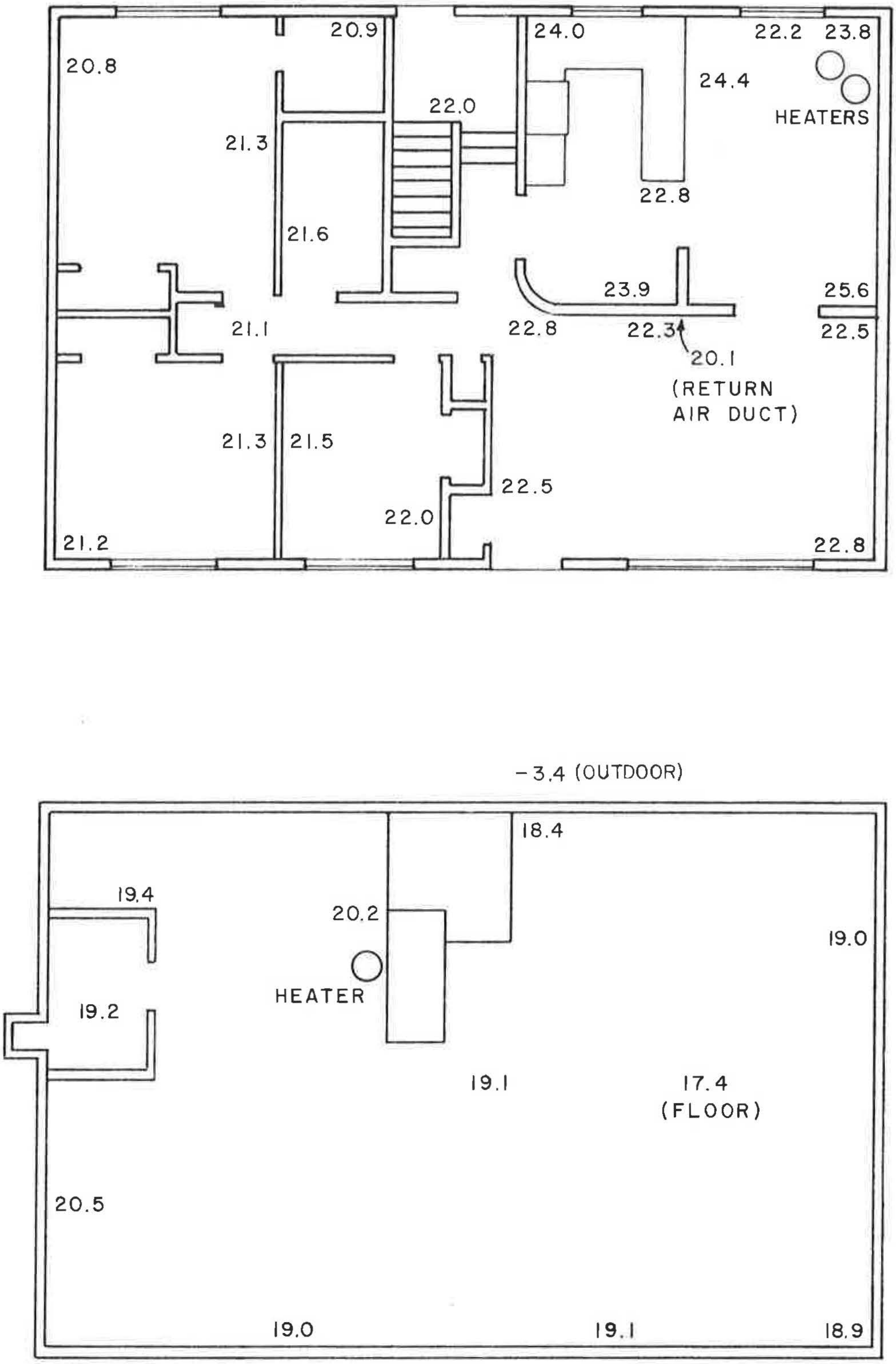

Figure 2 Point–source electric heat, heaters on, interior doors open, 2 March 1981.

During the closed-door tests the temperature variations became more significant. With a control point at 21.6°C and an outdoor temperature of 0.3°C, the coldest indoor temperature was 15.8°C in the southwest bedroom and the warmest indoor temperature was 25.6°C close to the heaters. Average temperatures in the same spaces were 16.0°C and 22.9°C. The temperature in the hallway outside the bedroom door was 21.3°C, very close to the control point. The difference between the control point temperature and the temperature of the coldest bedroom is about 27% of the total difference between the central point and outdoor temperatures. This indicates that the effective resistance of the room envelope adjacent to the other heated spaces played a significant role in the heat loss through the far bedroom. This was due, in part, to the small surface area adjacent to spaces close to the control temperature, and possibly also to lower than normal convective heat transfer coefficients for air undisturbed by human passage or mechanical means and large losses from the window.

Temperatures in other parts of the house were not so cool as those in the corner bedroom, generally hovering between 17°C and 18.5°C where a room was shut off from the control space. The open-door condition shows that with more natural convection the temperature distribution was much more uniform. This could be accomplished in similar houses by installing louvered or screened openings above or through partition doors. A more even temperature distribution could also be obtained by placing the point-source heaters at either end of the house. Such installations may reduce the capital cost of a heating system and permit the operation of one of the zones at a slightly lower temperature. It must be noted, however, that an installation may not perform as intended if heaters are far removed from a point of major heat loss or where there is inadequate opportunity for convective flow. Two or perhaps three heaters should be the very minimum, and they should be located so as to provide a good link to all heated spaces.

The heat loss characteristic for the Milbrandt house was reported as 8.25 W/K in a previous paper [2]. A cool-down test performed on the house gave a cooling time constant, τ, of 60 h. This indicates a heat capacity of 17.8 MJ/K, which is approximately equal to that determined by the Barakat and Sander method for a medium weight building [3]. The time constant is substantially longer than that for normal construction owing to the low heat loss characteristic.

Overheating

Figure 4 shows the temperature distribution in the house at the time of the highest average indoor temperature. Table 2 gives average temperatures for spaces on the south and north sides of the house, 19 August 1981 at 17.23 h. The only internal gain at this time was 125 W required by the temperature recording data logger. The highest measured air temperature was 33.5°C near the large south-facing window in the living room. The coolest temperature was 22.9°C in the basement. During the period of test the house was completely sealed; the chimney, combustion air inlet, heat exchanger, and all other vents were blocked. No forced-air circulation was employed. The average temperature was 29.1°C on the main floor and 23.6°C in the basement; outdoor temperature at the time was 31.7°C. The coolest average temperature on 19 August was 26.0°C on the main floor and 22.9°C in the basement. This occurred at 07.00 h. The outdoor temperature at the time was 13.7°C, indicating that a substantial amount of free cooling could have taken place overnight had some form of ventilation been employed. Total horizontal insolation for the day was 22.4 MJ/m^2 and the electrical energy consumption was 6.8 MJ for the 24-h period.

TABLE 2. Space Temperatures to Demonstrate Overheating (Fig. 4)

South Side		North Side	
Living room	29.4	Master bedroom	27.5
Bedroom 3	28.8	Hall	28.6
Bedroom 2	28.3	Kitchen/dining	29.9
(corner)		Basement	23.5

CONCLUSION

The high thermal resistance of the building envelope of a low-energy house in Saskatoon, with an associated thermal capacity of 17.8 MJ/K and low infiltration rate, allowed simplification of the electric heating system. This consisted of two point-sources, one of 3000 W capacity in an upstairs corner of the house and one of 2000 W capacity in the basement. With interior doors open and only natural convection as the driving force, the temperature distribution was very even. With the doors closed and natural convection suppressed, the temperature differences from the control point were significant, the maximum being -5.8 C deg. It is concluded that a simplified system can be used for low-energy houses if point-source heaters are judiciously placed and ventilation is provided between spaces. In spring, summer, and fall overheating can be a problem in low-energy houses if no cooling is provided at night when the ambient temperature is lower.

REFERENCES

1. Dumont, R.S., H.W. Orr, and M.E. Lux. Low energy Prairie housing, National Research Council of Canada, Division of Building Research, Building Practice Note 38, 1982.

2. Lux, M.E. Energy balances in the Milbrandt low-energy house. Presented to ASHRAE/DOE/BTECC Conference on Thermal Performance of the Exterior Envelope of Buildings, Clearwater Beach, Florida, December 1985.

3. Barakat, S.A., and D.M. Sander. Utilization of solar gain through windows for heating houses. National Research Council of Canada, Division of Building Research, Building Research Note 184, 1982.