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ADAPTABLE MODULES FOR AIR INFILTRATION STUDIES IN HOME HEATING

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The Alberta Home Heating Research Facility consists of six uninhabited wood frame single story modules with full basements, designed to test domestic heating strategies in a northern climate. The facility is located on the University of Alberta experimental farm near the city of Edmonton, at 53°N latitude. Each module is 6.7m x 7.3m in plan, with a floor area of $49m^2$, about 40% to 50% of the area of a full scale single family detached house. The wall heights of 2.45m in basement and upper level are full scale, as are the double-glazed window units, whose area is adjusted to the smaller wall area, see Table 1. The facility is described in detail by Gilpin et. al. (1979).

The strategies presently under study are 1.) conservation through increased insulation and reduced infiltration 2.) passive solar heating with south facing windows and interior masonery storage walls 3.) active air solar heating using pebble bed storage and 4.) active liquid solar heating using tank storage. The other two modules are a standard unit with insulation and construction typical of Canadian standards from 1950 to 1975 (see Table 1), and a short term testing module with 2.45 x 2.45m removable wall panels to permit field testing of special wall and window types. The standard module will not be modified in the forseeable future, allowing direct comparison of diurnal weather effects. Meterological data including wind speed at three heights, wet and dry bulb temperatures and total solar radiation has been collected at a tower about 500m from the site for over ten years to provide a data base.

The modules are all electrically heated to allow accurate measurement of input, and power meters and data logging systems are located in the short term module to minimize uncontrolled infiltration from frequent entry. The active solar heating will provide at most about 20% of the annual load, typical of retrofit installations in a northern climate.

Base-line heating requirements with no active solar heating has been monitored since the end of November 1979, and is shown in Fig.1. As expected, energy consumption is in inverse order of insulation levels, and within ±15% of calculated values using standard ASHRAE methods. It was particularly gratifying to find the losses from the identically insulated active solar modules to be within ±0.6% of each other on a cumulative basis.

Capabilities for Infiltration Studies

The six modules are arranged in an east-west row spaced 2.5m apart with identical solar and wind exposures (a false wall provides shading and shelter for one end unit). Infiltration studies are facilitated by the following features:

1.) Freedom to erect shelter barriers to reduce wind infiltration. The flat terrain site is suitable for analysis and wind tunnel simulation.

2.) Large winter temperature differences, typically 30°C and often 40°C, combined with calm nights, should allow separation of stack and wind effects.

3.) No internal rooms or cupboards are present to cause multi-cell lag times for tracer gas studies.

4.) Small size and no occupants makes the units easy and economical to modify, and permanent standard unit is available for constant comparison.

The major disadvantage of the facility is the small size of the modules, which will require some scaling of wall area, crack length and flue size to assess the effect of a particular infiltration component on a full scale house. However, the use of the standard module as a comparison should reduce this scaling problem to some extent in assessing the relative merit of modifications.

Infiltration Measurements

A series of preliminary time-decay infiltration measurements were made in the period Jan 24 to Feb 18, 1980, using SF_6 as a tracer. The tracer was fed into the return air duct of the electric furnace until the concentration reached about 5ppm. This level was about 20 times the minimum detection limit of the Wilkes Miran 1A infra-red spectrometer used. The circulating fan on the furnace was operated continuously and the concentration-time profile plotted on a strip chart recorder.

The duration of each test was varied in an attempt to sample during unchanging weather conditions. Typical test times of 3 to 10 hours were used, although for air exchange rates below 0.15 changes per hour, this was extended to 14 to 22 hours to obtain significant concentration differences. The semi-log concentration-time plots showed some departure from the perfect mixing straight line, with the data indicating lower concentrations than predicted by perfect mixing. This shape of concentration-time curve suggests, according to the models of Hunt and Burch (1974), that there were no dead volumes, but that infiltration pushed out tracer marked air before it could mix perfectly with infiltration.

As expected, infiltration rates increased with wind speed and temperature difference. A set of typical exchange rates for the six modules is shown in Fig.2, with an experimental uncertainty of about ±10% due to weather variations between tests. The largest single contribution to infiltration was caused by the simulated gas furnace vent through the roof, (see Table 1). Tests in the passive solar and short term modules with the vent pipe blocked reduced infiltration rates by about 0.2 to 0.3 changes per hour. Thus, most of the low infiltration rate observed for the conservation module was due to the absence of a vent stack, although the 0.15mm vapour barrier and 20cm of laminated rigid foam block insulation contributed to the very low observed rate of 0.08 per hour.

In conclusion, the test facility is behaving much as expected, and a sampling system for simultaneous infiltration measurements in all six modules, combined with a pulsed release to maintain constant concentration levels, is planned for future studies.

Acknowledgements

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References

1.) Gilpin, R.R., Sadler, G.W., Dale, J.D., Forest, T. and Rachuk, T. (1979) "The Alberta Home Heating Research Facility" paper 79-94 Solar Energy Society of Canada Annual Meeting Charlottetown, August 1979.

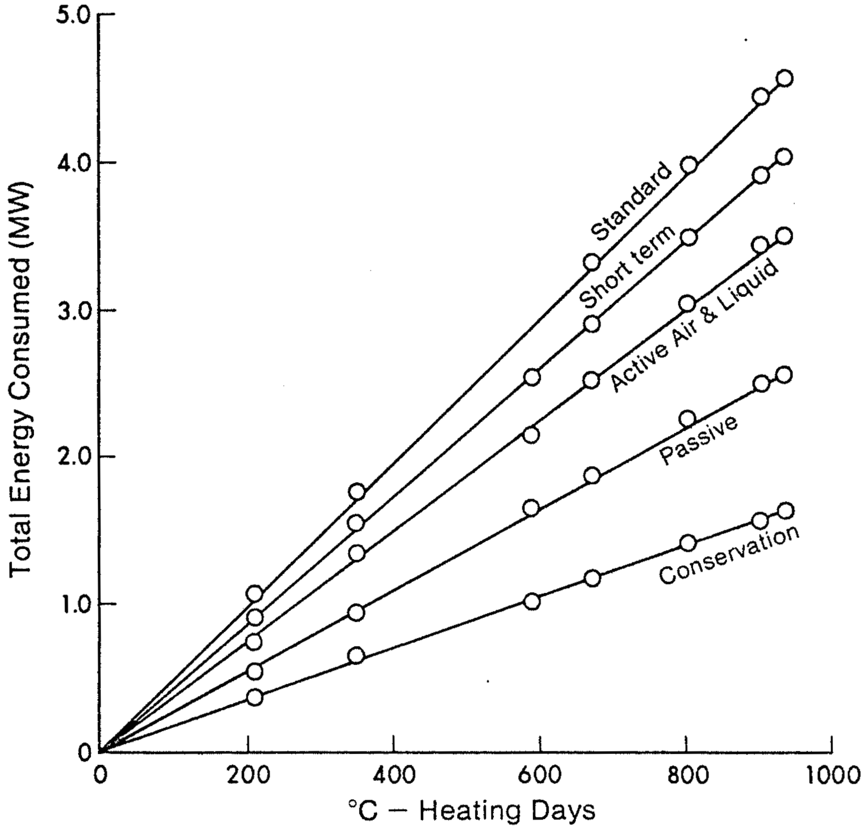
2.) Hunt, C.M. and Burch, D.M. (1974) "Air Infiltration Measurements in a Four-Bedroom Townhouse Using Sulphur Hexaflouride as a Tracer Gas" ASHRAE paper 2338.

Table 1

Insulation and Infiltration Details of Modules

Module	Insulation			Flue Diameter cm	Air and Vapor Barrier mm	Double Glazed Windows % floor area	
	Ceiling	Walls	Basement				
Standard	R-12	R-8	none	15	0.10	11.9%	typical 1950-1975 residential construction
Short Term	R-12	R-10	R-10 to 0.6m*	15	0.10	11.9%	windows on removable 1.22 x 2.45m panels
Active Air	R-12	R-10	R-10 to 0.6m	15	0.10	11.9%	collectors not yet installed on south wall
Active Liquid	R-12	R-10	R-10 to 0.6m	15	0.10	11.9%	
Passive	R-40	R-20	R-10 to 2.45m	15	0.15	25%	insulating window shutters and thermal mass not installed
Conservation	R-80	R-40	R-20 to 2.45m	none	0.15	13.7%	vapour barrier outside studs on inner side of rigid foam

* depth below grade



Preliminary measurements of energy consumption as a function of heating degree days for the six modules. The Conservation module uses about one-third of the energy required by the Standard module.

Figure 1

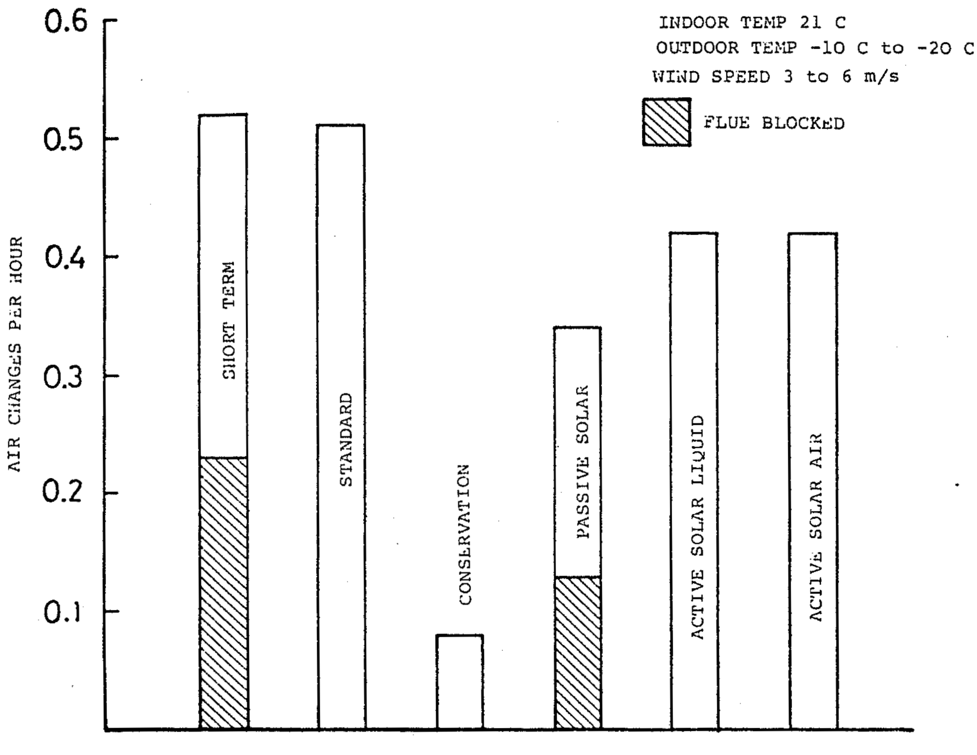


Figure 2