DEVELOPMENT AND PERFORMANCE OF MOVABLE SUNSPACES IN APARTMENT BUILDINGS

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1. Introduction

Movable sunspaces in apartment buildings allow in a simple way the passive use of solar energy during the winter season.
Many existing residential houses have facades with balconies. In this case sunspaces are the only possibility to reduce the heat loss of the facade. Five different systems of movable sunspaces were developed in co-operation with Swiss industry. Eight sunspaces were installed in an apartment building and their performance was monitored during three winter seasons. The sunspaces were equiped with single glazing in the first winter. The following year different double and triple glazings were installed. During the last winter season the apartments were monitored without the sunspaces.

2. Description of the building and the sunspaces

The eight monitored apartments are located in a six floor high and south-oriented building. Figure 1 shows the facade of the building with the sunspaces. The mean U-value of the apartments is 1.8 W/m^2K because of the great window area and the badly insulated walls. The ground-plan of the flats is shown in figure 2.

Fig.1. Test building with sunspaces

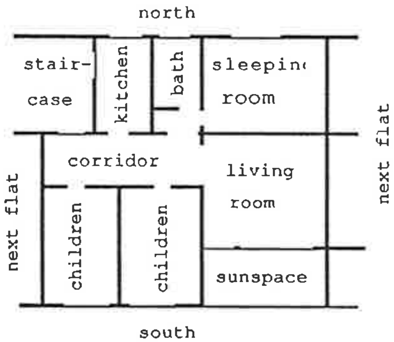

Fig.2. Ground-plan of apartments

The dimensions of the sunspaces are 4.5m x 1.8m x 2.7m. The glazing area is equal to the floor area ($\cong 8m^2$). Though the movable glazing systems are different to open, they all can completely be opened in summer. Figure 3 shows an overview of the different systems.

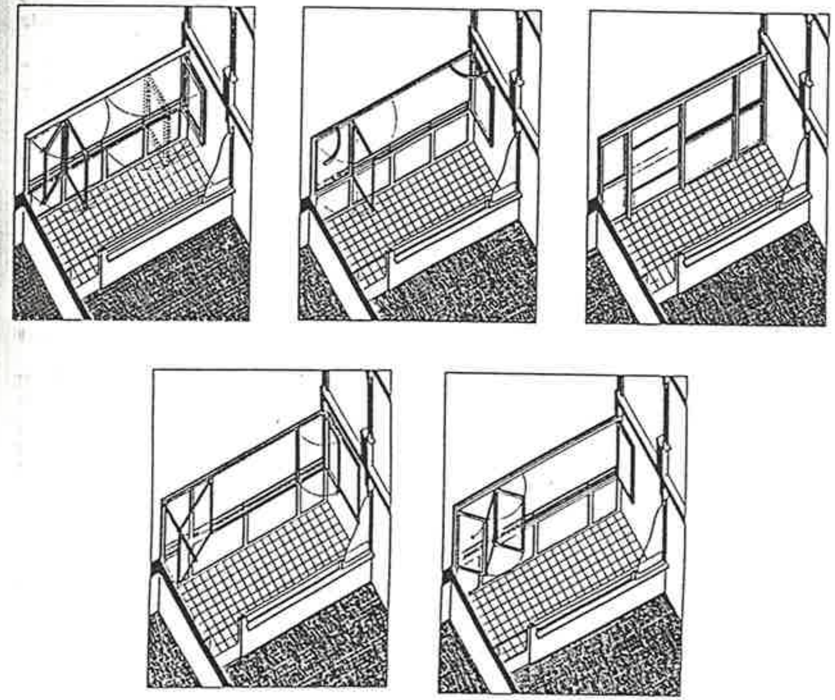

Fig.3. The movable glazing systems

The frames of the systems are all made of aluminium and are not insulated. They can be equiped with single, double and triple glazing. Figure 4 and 5 show two sunspaces from the inside.

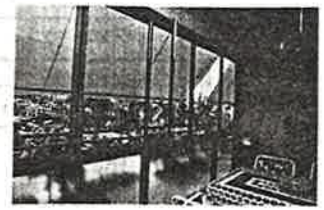

Fig.4. sunspace from inside

Fig.5. sunspace from inside

3. Measurements and Data Collection

In order to study the effect of the sunspaces on heat energy consumption and the behaviour of the sunspace climate the following quantities were monitored:
- climatic data (outdoor temperature, global and diffuse solar radiation, wind speed, air humidity)
- sunspace and indoor air temperature
- auxiliary heat consumption
- position of the sunspace windows and the door between sunspace and apartment

The outputs of the sensors were transfered to a personal computer which averaged and recorded the data each hour. The data acquisition scheme is shown in figure 6.

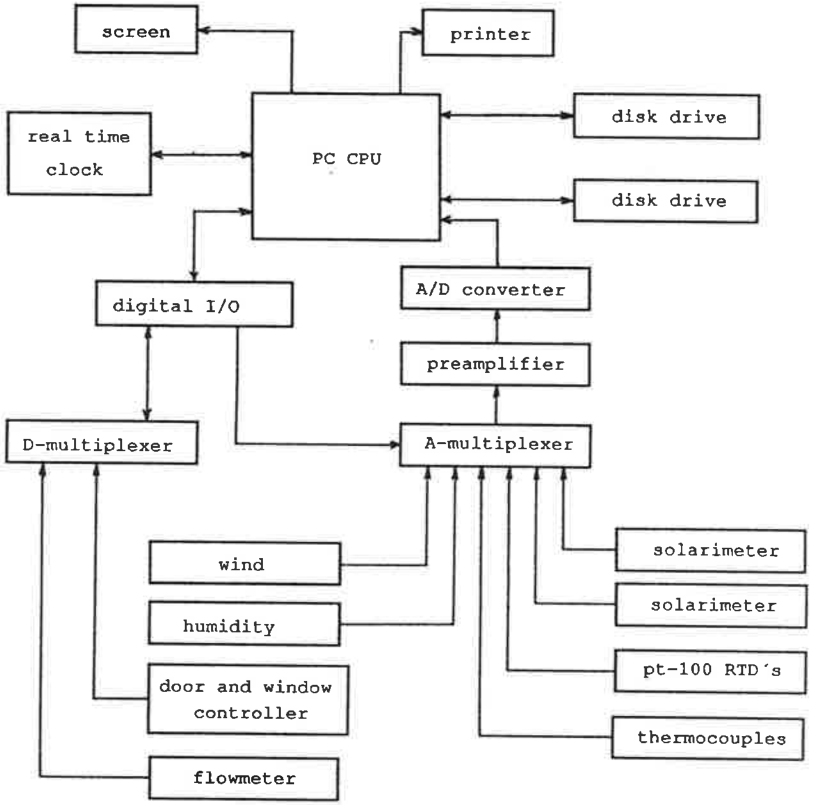

Fig.6. Data acquisition scheme

4. Results

4.1. General Results

The following conclusions have been obtained through the experiences of the occupants:

- the sunspaces shelter from noise, wind and dust
- it should be possible to close the glazing in summer too in order to use the sunspaces on rainy days and cool nights
- the way how to open the system is not very important to the user. All occupants were satisfied with their allocated sunspace
- the systems should be easy to handle and to clean. This requirement was fulfilled by most of the studied systems
- water condensation occuring on single glazing is a big problem, but correct airing and low absolute indoor humidity can prevent the condensation
- the blinds were rarely used because overheating was not a problem

4.2. Sunspace climate

The sunspaces were equiped with single glazing in the winter 1984/85 and with double/triple glazing in the winter 1985/86. In order to compare the results of the two periods with different outdoor climate the data measurements is analyzed by a multi-linear regression of the form:

$$T_{ss} = a\ T_{out} + b\ G_v + T_o$$

where T_{ss}: sunspace air temperature
T_{out}: outdoor temperature
G_v: vertical south radiation

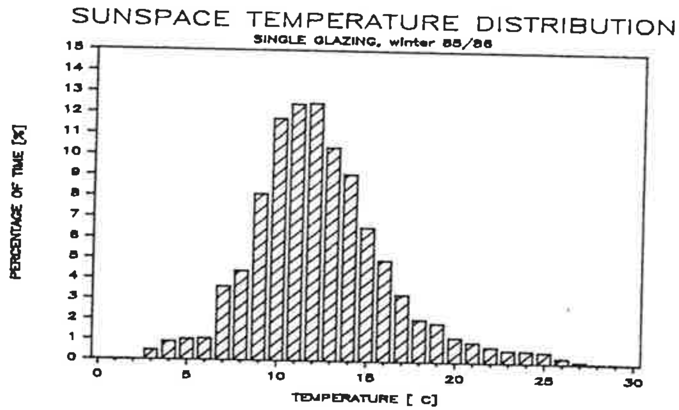

Fig.7. Sunspace temperature distribution for single glazing

Figure 7 and 8 show the sunspace temperature distributions for single and triple glazing estimated for the outdoor climate of winter 1985/86 by multi-linear regression of the data measurements. Triple glazing stabilizes the sunspace climate. With single glazing the temperature is in a wider range and even falls under zero for few hours.

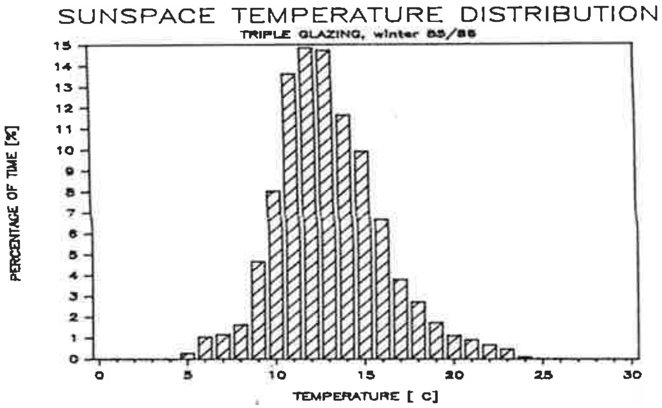

Fig.8. Sunspace temperature distribution for triple glazing

The monthly average of the daily sunspace temperature course for single and triple glazing of two extremely cold months (Jan 85 and Feb 86) is drawn in figure 9. The data measurements show no difference in temperature between double, infrared coated double and triple glazing.

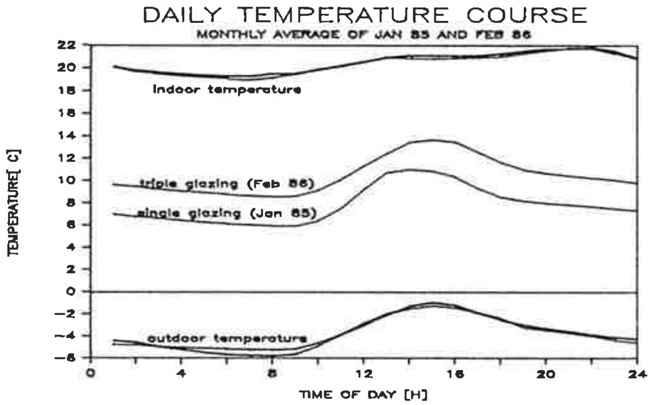

Fig.9. Daily sunspace temperature course for cold days

4.3 Heat energy consumption

To analyze the effect of the single and double/triple glazing sunspaces on the heat energy consumption of the apartments three months of the three different winters (Jan 85, Feb 86 and Jan 87) with nearly the same average outdoor temperature are taken. The energy consumptions are corrected with regard to outdoor and indoor temperature. Figure 10 show the heat consumption of the apartments without (NO) and with single (SG), double (DG) and triple (TG) glazing sunspaces. The consumption is devided in three parts: the consumption of the room behind the sunspace (living room), the room besides and the remaining rooms of the flat.

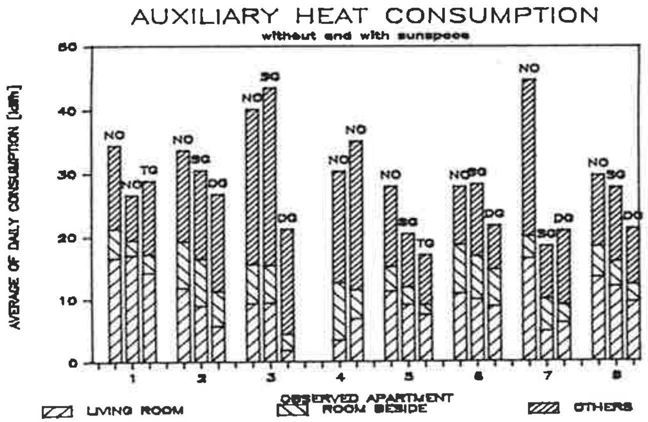

Fig.10. Heat energy consumption of the observed apartments

The occupants of apartment 4 did not use the sunspace, they always let the glazing open. In apartment 7 the occupants have changed. For that

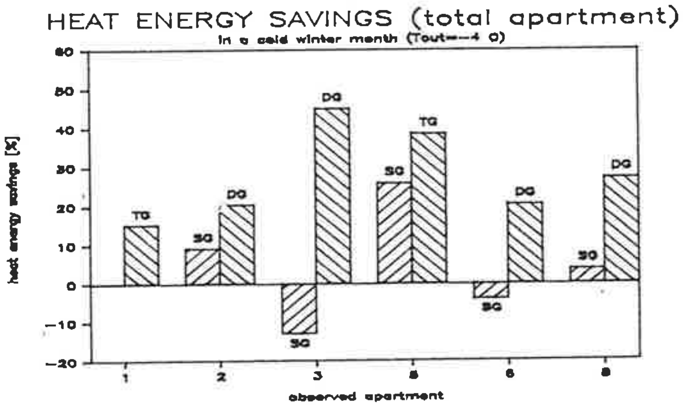

Fig.11. Energy savings to the whole apartment

reason these two apartments will not be considered in the further discussion. The heat energy savings with double glazing sunspaces are evident (Figure 12) with respect to the living room which is behind the sunspace, but even to the whole apartment (Figure 11). The effect of

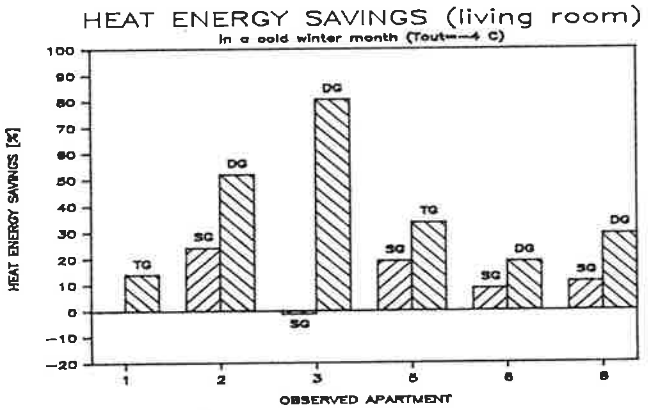

Fig.12. Energy savings to the room behind the sunspace

the single glazing sunspaces on the heat consumption is not so definite. The behaviour of the occupants is more important. Opened doors to the sunspace can lead to an increase of heat consumption (Figure 13 : apartment 3).

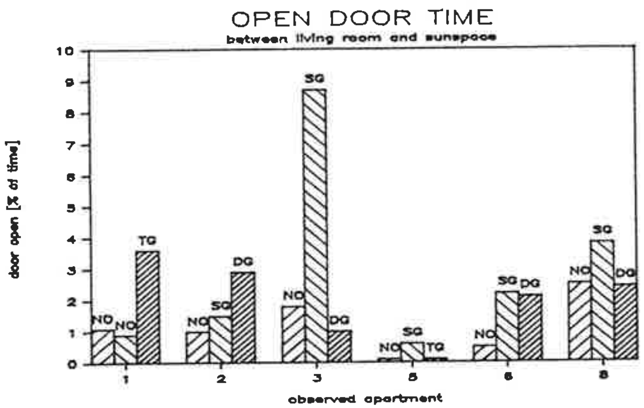

Fig.13. time of opened door between room and sunspace

5. Conclusions

The following conclusions can be drawn from the measurements:

- the monitored movable sunspaces are efficient in saving heat energy
- single glazing sunspaces are very sensitive to the behaviour of the occupants. Problems with condensed water on single glazing lead to an increase in the time of opened door between room and sunspace. This can even result in an augmentation of heat energy consumption. For that reason single glazing should only be used if the occupants pay attention to the fact that low absolute indoor humidity and temperature can prevent the condensation of water.
- double glazing sunspaces have reduced the heat energy consumption in all observed apartments. The average reduction is 28%.
- infrared coated double glazing and triple glazing increase the thermal comfort, but no significant differences in heat energy savings and sunspace air temperature were measured in respect to double glazing
- the coefficients of the multi-linear regression for the sunspace air temperature are (see 4.2.):

	single glazing	triple glazing
a ( )	0.554 ± 0.007	0.446 ± 0.006
b (°C/Wh)	0.0111 ± 0.0003	0.0082 ± 0.0002
T_o (°C)	10.9	11.7

6. References

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