HOW PEOPLE USE THEIR SUNSPACES

Effect on 'heating need' estimates

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At 'Les Balcons de Velchée', a group of flats in Eastern France, the south-west façades have fully glazed enclosures to exploit solar gain. This paper from the Sophia-Antipolis division of the CSTB reports a detailed investigation which showed that occupants do not follow the 'standard' behaviour assumed in heating need calculations. The effect on actual thermal performance is significant, though the energy-saving advantages of sunspaces are still considerable.

The article is based on a paper given at the 1986 Lisbon symposium of CIB working commission W67.

Aux 'Balcons de Velchée', groupe d'immeubles près de Nancy, dans l'est de la France, les façades sud-ouest sont entièrement vitrées pour profiter des apports solaires. Cet article de la division de Sophia-Antipolis du CSTB expose les détails d'une enquête qui a montré que les occupants n'ont pas, en fait, le comportement sur lequel étaient basés les calculs des besoins de chauffage. L'incidence de cet état de chose sur les performances thermiques réelles est importante mais les économies d'énergie réalisées grâce aux vérandas sont malgré tout considérables.

Cet article est basé sur une communication faite au symposium de Lisbonne de la W 67.

The solutions involving attached sunspaces (verandas, conservatories or any glazed spaces) are among the most interesting passive solar techniques for energy conservation in buildings. In addition to the interest presented by this technique from the point of view of energy, an attached sunspace creates extra living space. Consequently, the behaviour of the occupants may have an influence on the thermal performance of this technique.

In the framework of a large measurement programme conducted on the experimental buildings of 'Les Balcons de Velchée', the CSTB (Centre Scientifique et Technique du Batiment) was asked to arrange, with the help of HLM (Société Anonyme d'Habitations à Loyer Modéré de l'Est), the building owner, a specific study of the sunspaces on the façades of the buildings.

The main goals of this study were:

- to monitor the behaviour of the occupants relative to the sunspaces and to the various elements (openings, shadings, doors and windows between living spaces and sunspaces).
- to collect experimental data in order to evaluate the comfort (both from the thermal and global points of view) provided by the sunspaces and the actual energy effect of the sunspaces.

To meet these goals, the following studies were made:

- an investigation into the use of the sunspaces
- observations on the use of the shading system
- measurements in some of the sunspaces and the living-rooms

This paper presents the main results obtained. More details have been reported in reference 1.

The dwellings and their sunspaces

'Les Balcons de Velchée' constitute a group of 186 rental flats built at Malzéville, near Nancy, Eastern France. The six buildings are 2 to 9 storeys high. Their curved shape follows the curved working face of an old quarry, on which they are built and which protects them against the northern winds. (Fig. 1 shows a layout plan of the buildings.) The main façades of the buildings on which the living-rooms and most of the rooms are situated, face between south and west, depending on

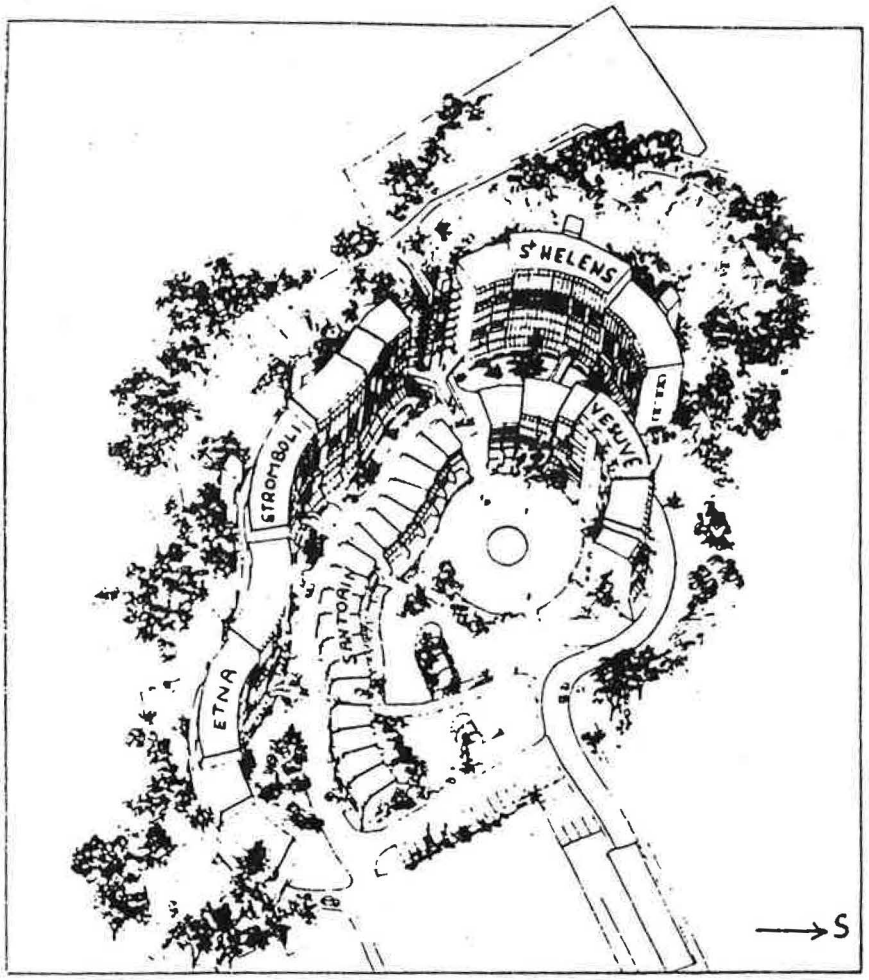

Fig. 1. Layout plan of the group of buildings near Nancy

the building considered. These façades are equipped alternately with balconies and sunspaces (fig. 2). The sunspaces are generally a prolongation of the living-rooms; the partitions between living-rooms and sunspaces or balconies are almost totally composed of windows, those opening onto the balconies having double glazing.

On the opposite side, the ratio of glazing area of the north façade, which is equipped with alleyways, has been reduced to about 20 percent. The global heat loss coefficient of the buildings is around 0.75 W/m^3/K.

Sunspaces' significance and utility

This investigation was conducted by distributing a questionnaire to every family living in the residence; 93 out of the 183 questionnaires were mailed back and their answers analysed.

A large majority of the answers (71 percent) showed a very clear satisfaction with the sunspace, 20 percent of the people even declaring themselves 'very satisfied'. Only a few people (5 percent) seemed not to appreciate this facility, putting forward its lack of usefulness. 84 percent of the people thought there would be a development of that kind of sunspaced building, mainly on account of its aesthetics (80 percent of the answers), of the comfort it provides (80 percent) and of the energy savings and the heat supply (only 21 percent).

However, this general high marking did not prevent people from expressing some criticisms and hoping for improvements, such as a better water tightness. This satisfaction found expression in the desire of 79 percent of the people for a sunspaced dwelling if they had to move some day. Onlu 10 percent of the people would then seek dwellings with no sunspace.

Nevertheless, it was clear that the thermal feature of the sunspace was not much perceived by the occupants. Thus, only 9 percent spoke of the heat provided by the sunspace as an advantage, and only 3 percent gave solar energy as grounds for a possible development of sunspaces.

Use of the sunspaces

The influence on the thermal behaviour of a building of an attached sunspace depends largely on the way the occupants make use of the space and of its various elements.

Four main kinds of use emerged from the answers, garden-space (more than 50 percent of the answers), dining-space (39 percent, drawing-space (28 percent) and playing-space (25 percent).

The large use of the sunspace for purposes other than a 'garden' often led people to arrange it specifically with carpeting, drawing-room furniture, particular lighting, paintings, posters or odds and ends; 3 people (but only 3) had even installed a heating system. However, garden furniture was the most frequently observed. Only 17 percent of the sunspaces had no permanent furniture.

Consequently, it appears that, for 60 percent of cases, the sunspace may be occupied for a great part of the day. However, questions concerning the breakdown of the utilisation by seasons showed that only 30 percent of the people may sometimes stay in their sunspace in winter time. For instance, dining in the sunspace was exclusively in summer.

In fact, winter use of the sunspace was restricted both in time and in frequency, either for watering plants, or for pottering about, or just for staying in it at times when the sun was heating the space. One person out of 4 (i.e. 8 percent of the answers) said that, when it was too cold, he then warmed up the sunspace by opening the French window of the living-room.

Use of the movable elements of the sunspace

Other questions related to the use made of the glazed openings of the sunspace; of the inside roller blinds of the sunspace; and of the French window between the living-room and the sunspace.

The utilisation of the openings in winter time seemed to be rather frequent. The mean value of the opening duration could be estimated at about 1 hour.

The roller blinds were generally lowered at night by 40 percent of the people. During the day they were 'often' in the down position in summer time in 77 percent of the cases, and in winter time in one percent of the cases. In 12 percent of the cases, they were said to be 'sometimes' in the down position in winter time. A great number of people (40 percent) were used to lowering their blinds between seasons in oder to be protected against solar radiation.

The French window between the living-room and the sunspace was generally kept closed in winter time. However, 48 percent of the people said they set the window ajar 'often' or 'sometimes' during the day. For two thirds of them, they used to open or close the window depending on the temperature in the sunspace. Lastly, it may be noted that half of the people regretted that no shutter was installed on that window.

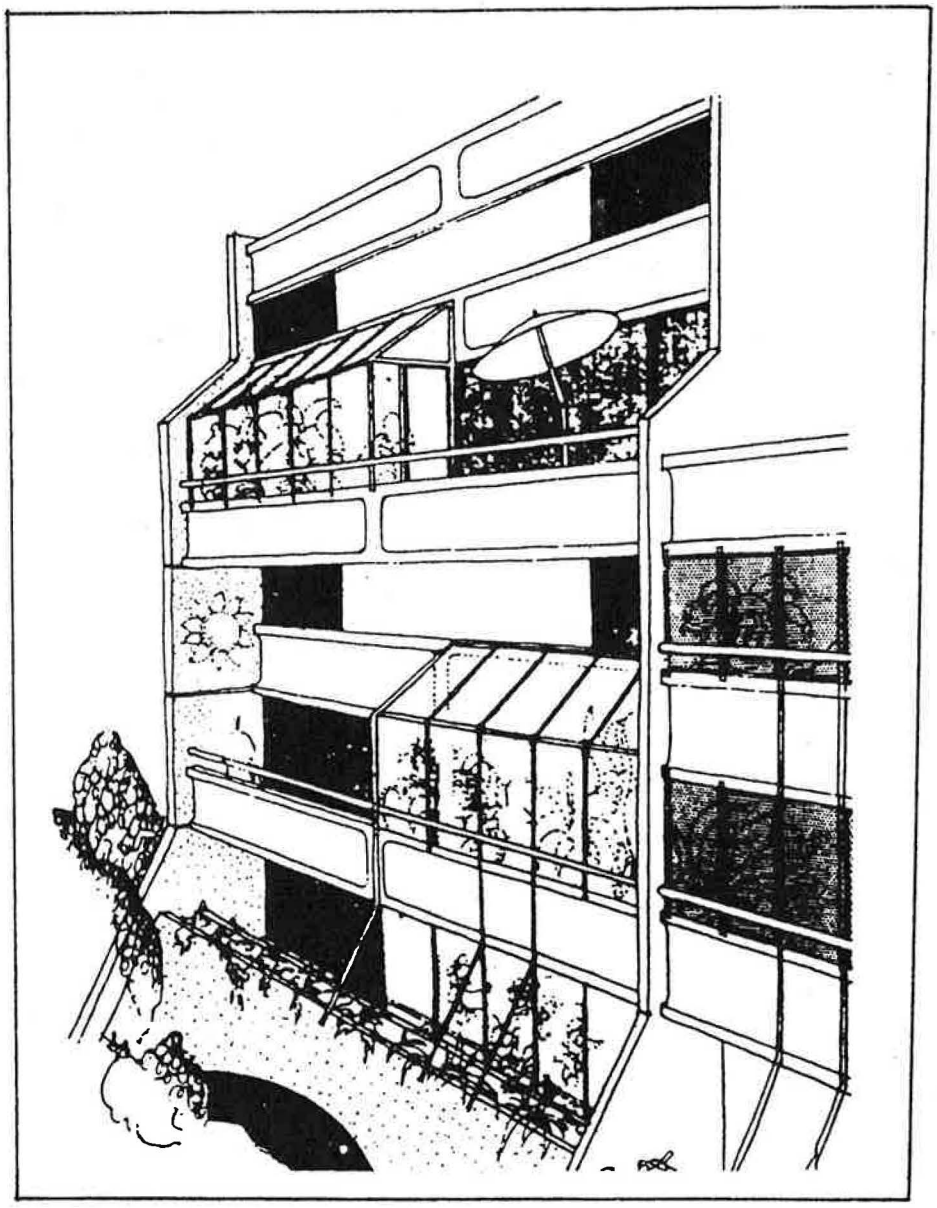

Fig. 2. Sketch of a typical façade with the built-in sunspaces

Comfort in summer time

75 percent of the people who answered the questionnaire said it was 'often' or 'very often' too hot in the sunspace and in the living-room in summer time. Using the shading blinds or the openings of the sunspace was judged effective by only 40 percent. Nevertheless, only 11 percent mentioned overheating as a criticism against the sunspace and the dwelling. Consequently, it does not seem that overheating, though actually experienced, was a major problem.

Use of inside roller blinds

The evaluation of the energy savings provided by a sunspace depends largely on the value of the solar input into the space. Knowing how the occupants in winter time make use of the roller blinds installed on the glazings of the sunspace is thus very important. The observations carried out at 'Les Balcons de Velchée' showed that, in winter time, about 20 percent of the total glazed area of the sunspace was covered with the roller blinds.

Monitoring the temperatures.

Temperatures in the sunspaces and in the living-rooms, and of the French window between the sunspace and the living-room, were monitored from April 1982 to April 1983 in five flats in one of the buildings.

Comfort in summer

The presence of an attached sunspace on a building may lead, if some precautions have not been taken at the design stage, to overheating in summer and even between seasons. A good solar protection, with the feasibility of opening some glazing of the sunspace in order to ensure some ventilation, are the best means of avoiding this overheating. Outside shading (overhangs, blinds) is, in that respect, the best solution. Inside shading (blinds, curtains) is less efficient but also generally less expensive.

Consequently, it seemed interesting to study the thermal comfort obtained at 'Les Balcons de Velchée' where the sunspaces are equipped with inside roller blinds and moreover with a rather small opening area.

The highest temperature recorded in the living-rooms during summer 1982 was 30.5°C, with a highest ambient temperature reached on the day in question equal to 23.4°C. Considering the French regulation relative to thermal comfort in buildings officially labelled as low-energy buildings, it is interesting to analyse the conditions under which the living-room temperature went over 27°C. This regulation lays down that this room should be maintained within the limit of 27°C at least whenever the daily ambient temperature is under a certain limit, which is fixed at 22°C for the region in question. It appears that this requirement was not met at least five times during the month of July 1982. The overstepping of the maximum permitted temperature in the living-rooms has been evaluated at 2°C. However, the answers to the questionnaire showed that the occupants tolerated this condition.

Table 1 gives, as an average for the five flats, the highest temperatures recorded in the living-rooms and in the sunspaces from April 1982 to September 1982.

Temperatures during the heating period

Table 2 gives the mean monthly temperatures and the highest and the lowest temperatures recorded in the sunspaces from October 1982 to April 1983.

The analysis of the recorded temperature variations shows that:

- The sunspace temperature is rather high even without sunshine. Thus, the average sunspace temperature without sunshine was about 10°C in January, and the lowest recorded sunspace temperature was around 6°C. This can be explained by the fact that the heat transfer coefficient between the living-room and the sunspace has a rather high value due to the large glazing area between the two rooms.
- The sunspace temperature rises very high whenever the sun is shining. This was very clear in March when the temperatures recorded in the spaces easily reached 30°C during the first two weeks.
- The sunspace temperature hardly ever rises above 20°C in December, January and February, through lack of sunshine.

- Conversely, the sunspace temperature rises rather often above 20°C in October, early November, March and April.

Analysis of heating needs

Heating need calculations have been carried out, based on the example of 'Les Balcons de Velchée' in order:

- to determine the influence of the main façade of the buildings on the energy savings and thus to justify the chosen design.
- to compare the *anticipated* gain from the sunspace with the *actual gain* resulting from the actual behaviour of the occupants.

The calculations have been carried out by following the widely used French calculation method 'Règles Th-B' (ref. 2) and by using the data obtained from the investigation and the observations reported above. Tables 3 and 4 give the main results of these calculations.

The gain anticipated by adding the sunspace is equal to 0.18 W/m^3/K. However, it appears that the gain provided by the chosen solution with the sunspace is only 0.02 when comparing it with the best solution without sunspace.

Concerning the influence of the behaviour of the occupants it can be noted that extreme behaviour leads to large increases in the heating needs, equal to 0.21 W/m^3/K when heating the sunspace; 0.16 when keeping the window between the living-room and the sunspace always wide open; and 0.10 when keeping it just ajar. Keeping the roller blinds always in the down position leads to a smaller increase, equal to 0.04 W/m^3/K.

Fortunately, the average behaviour observed at 'Les Balcons de Velchée' was not quite so unfavourable. This average behaviour can be defined as follows (the influence on the heating needs in brackets):

- keeping the roller blinds in the down position for 20 percent of the cases (0.01 W/m^3/K)
- keeping the windows of the sunspace open for 5 per cent of the cases (0.01)
- keeping the French window ajar for 15 percent of the cases (0.015).

The heating needs resulting from this average behaviour are equal to about 0.55 W/m^3/K. This value represents the average heating needs of the flats of 'Les Balcons de Velchée', when taking into account the observed behaviour of the occupants.

Table 1. Highest temperatures recorded, 1982

Highest temperature (°C)	April	May	June	July	Aug.	Sept.
Living-room	21.5	25.7	30.1	30.6	27.6	28.2
Sunspace	26.2	33.5	33.0	34.4	31.0	33.4

Table 2. Temperatures recorded during the heating season, 1982–83

Sunspace temperature (°C)	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Highest temperature	31.2	28.2	17.6	23.4	22.7	29.8	23.4
Mean temperature	16.8	11.4	10.4	11.6	11.4	14.9	16.0
Lowest temperature	12.3	7.6	6.9	6.6	6.2	8.0	10.7

Table 3. Influence of main façade design on heating needs

	Heating needs (W/m^3/K)
Standard flat of 'Les Balcons de Velchée'	
with sunspace	0.51
without sunspace	0.69
Similar flat but without sunspace	
+ double glazing	0.62
+ double glazing + shutters	0.57
+ double glazing + shutters + windows reduced to half their area	0.53

Table 4. Influence of occupant behaviour on heating needs. Standard flat with sunspace

	Heating needs (W/m^3/K)
Standard occupant's behaviour: blinds always in up position, sunspace openings and French windows always closed	0.51
Heating of the sunspace	0.72
French windows always wide open	0.67
French windows always kept ajar	0.61
Openings of the sunspace always kept open	0.60 to 0.70
Inside roller blinds of the sunspace always in the down position	0.55
Average for behaviour of the occupants	*0.55*

Conclusion.

The investigation carried out among the tenants of the residence 'Les Balcons de Velchée' has shown a very high degree of satisfaction with the flats equipped with an attached sunspace. But it has also appeared clearly that this sunspace is considered by the majority more as a facility improving the comfort and the aesthetics of the buildings rather than as one presenting any interest from the point of view of energy savings.

It appeared that 75 percent of the people think it is often too hot in the sunspace and in the living-room, but it seems that this overheating is well accepted. The records show that the temperatures observed in the living-rooms never rise above 30.5°C.

The evaluation of the energy savings provided by a sunspace depend largely on the way the occupants make use of the various elements of the sunspace (openings, blinds, French window between the sunspace and the living-room). The results obtained show that:

- the opening of the windows of the sunspace in winter time is quite frequent.
- 10 to 15 percent of the people leave the insider roller blinds of the sunspace almost always in the down position even in winter time. Moreover, 20 percent of the blinds appear to be in the down position at any given time in the heating period.
- 40 percent of the people keep the French window between the living-room and the sunspace almost always closed in winter time, while the remaining 60 percent open that window 'sometimes' or 'often'.

Heating need calculations have been carried out with various assumptions on

the design of the main façade of the building, and on the behaviour of the occupants. These calculations show that:

- Choosing a design with an attached sunspace and a large glazing area leads — *when considering the standard behaviour usually assumed* (blinds always up, openings of the sunspace and windows between the sunspace and the living-room always closed) — to heating needs slightly lower (by about 4 percent) than those represented by the best solution without sunspace (i.e. double glazing, good shutters, windows reduced to half of their total area).
- The average behaviour observed at 'Les Balcons de Velchée', however, leads to a decrease by 20 percent of the solar input from the sunspace to the living-room, and consequently an increase of the heating needs equal to 0.04 $W/m^3/K$.
- When taking into account this average behaviour, the appeal of the sunspace design seems therefore to recede somewhat, since the corresponding heating needs are then slightly higher (by about 3 percent) than those of the best solution without sunspace.

However, two aspects must be pointed out:

- firstly, an imperfect behaviour (window opening, shutters badly closed) should also be assigned to the solution without sunspace.
- secondly, the behaviour of the occupants has by no means cancelled the energy savings provided by the addition of a sunspace to a given façade design. It appears that, if the gain anticipated by considering a 'standard' behaviour was up to 26 percent, the decrease due to the actual behaviour was limited on average to a fifth of the anticipated gain. An energy saving of 20 percent, *when compared to the same dwellings without sunspace*, thus remains, together with the other advantages of this space to the occupants.

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