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Francesco Passerini

Sunspaces for passive building heating
Calculation models and utilization of empirical data

Supervisors: Prof. Antonio Frattari, Prof. Rossano Albatici (University of Trento)

Abstract

The thesis deals with sunspaces, considered as a particular passive solar system. Solar systems exploit solar radiation in order to decrease the use of non-renewable energy sources. Therefore their importance is both environmental and economic. According to "The passive solar energy books" (1979) of Edward Mazria the difference between "active systems" and "passive systems" is that in the latter the heat flows happen without mechanical equipment. The present research focuses on the reduction of winter energy requirements due to the presence of a sunspace, it analyses the involved physical phenomena, and it considers tools to design sunspaces and to optimize them from the point of view of energy requirements.

Particular attention is given to the quasi-steady-state methods, which are the most used by the designers. The thesis critically analyses calculation methods, identifies their problematic aspects and provides some indications to improve the method of the technical standard EN ISO 13790:2008.

As well as by the theoretical part, in the research a fundamental role is played by experimental campaigns. In fact, empirical data have been collected in relation both to existing sunspaces and to sunspaces which were specifically constructed for the research. Two sunspaces, one having the dimensions of a small room and the other one which is its scale model, with halved dimensions, were created and were the object of an experimental campaign. This experimental study has allowed to observe how the physical behaviour of sunspaces changes by changing their dimensions and to achieve a deep comprehension of sunspaces through quantitative analyses of involved physical quantities. A virtual model of the sunspaces was created and validated.

Because of the long renovation cycle for buildings, the improvement of the energy performance of existing buildings is fundamental. That is the reason why part of the research concerns the

refurbishments of verandas which are closed with elements having a large glazed surface. The concept is the same as for the sunspaces: the presence of an adjacent not heated space which works as "solar collector" can decrease the heating requirements. An existing building in Freiburg (Germany), which was renovated between 1997 and 1999 (among other things, by closing the veranda with windows, improving the insulation, and adding a solar air collector for the supply air entering the veranda and a mechanical air extraction system), was monitored (in collarboration with Fraunhofer ISE) and the data were analysed critically. Considering the experience with the past renovation, design proposals for future refurbishments have been considered. The energy performances of different possibilities are calculated and compared among them. Attention is paid to thermal insulation, to exploitation of the solar radiation and to ventilation strategies (also mechanical and integrated with heat recovery systems).

A guided procedure for the proper design of sunspaces is presented. Its goal is to present clearly and with a logical sequence what aspects the designers have to take into account to design sunspaces properly. Both new constructions and refurbishments are considered. Aspects such as the relationship between building shape and heating requirements, local context, insulation, thermal inertia, overheating, ventilation, and so on are dealt with.

The technology to build a sunspace is simple, but a rigorous study of its behaviour is complex. Future researches about the thermal behaviour of sunspaces could develop further the possibility to improve the quasi-steady-state methods, taking in consideration, also from a quantitative point of view, a lot of different cases. The utilization of CFD software, in order to better estimate the convective heat coefficients and to evaluate the ventilation from a sunspace, could be another development of this subject.