A General Model for Coolign Design

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Summary. To increase of diffusion on the bioclimatic architecture is necessary to make the calculation method easy to use for designers. In particular the available calculation method for analytical, based on transfer functions or finite elements method, or those made for simplified calculations, are generally very complex to use. Is necessary to devolop methods of analitical type and simplified more "friendly" to use. The present work shows the results obtained with a simulation model in respect with the previous conditions, to estimate heating and cooling systems performance, and also a simplified method, in wich operative graphs are used, for passive solar systems calculations and in progress partial results of a method for passive cooling.

1. INTRODUCTION

There are principally two types of analytical models to calculate the energetic performance of the buildings.
The first models is based on transfer function.
The second models is based on finite difference or finite elements methodology. The first models has best result when used on traditional buildings with simple building elements; and so isn't able to analyze bioclimatic complex structures.
The second systems, that used the thermal network, is more suitable in order to calculate the performance of bioclimatic complex structures.
It is necessary for both systems to have input data: that being hourly external conditions (solar radiation, temperature, relative humidity and wind direction and velocity) and geometrical and physicval characteristics of elements and systems of the building are indispensable.
An alternative for acheiving building performance results is the use of semplified methods.
The semplified method's is valid for standard conditions, but generally more complicated to use in particular for no-reference conditions. To resolve this problem it is necesary to consider two aspects:

- the first possibility of design is to make operative graphs or simplified correlations between the principal parameters (for climatic and physical/geometrical building's characteristics).
- the second possibility is to develop an analytical model with a simplified input data set.

This work shows the results obtained with:

- one simulation model, for heating and cooling, using easy input;
- one simplified method (using operative graphs) only for passive solar heating.
- in progress another group of operative graphs for coolign buildings design;
- the results of simulation for a new passive cooling component.

2. THE SIMULATION MODEL

The mathematical simulation model developed in the course of previous research /1/,/2/ was emploied for the energy optimization of a farming bioclimatic greenhouse for a natural control (without resorting to any heating or cooling systems) of the internal microclimate at all seasonal conditions (winter, summer, fall and spring) made for E.N.E.A. in Casaccia area fig. 1,2 For this greenhouse has been simulated and built two bioclimatic units fig 3,4. The first for passive solar heating and the second for passive cooling (based on evaporation and night radiation release system).

This simulation model, based on the thecnique of finite differences, enables the evaluation energy and hourly thermoigrometric behavior of both traditional and bioclimatic buildings with various types of passive solar heating and cooling systems.

This model expresses the behavior of buildings by means of an equation system representing the heat flow among the different subregions in wich the system has been devided. In order to solve such equations, the model resort to a differential numerical technique of one hour time intervals.

In this way, the system is represented in form of nodes. Each node represents a region of uniform temperature and has its own thermal capacity and is connected to the other (with wich interacts thermally) through a thermal conductance.

For each node, thermal balance equations consider the heat flow for irradiation, conduction, convection, evaporation, condensation, thermocirculation (Trombe walls, solar chimneys, etc.) as well as the thermal storage in the storage elements.

The temperature pattern, for each node, is simulated by solving such equations for a given hourly input of solar radiation, temperature and relative humidity of outside air, wind direction and speed. Other input data are naturally represented by thermophysical and geometric characteristics of building elements, on the other hand, output data are as follows:

- temperature and relative humidity of internal air, of radiant mean temperature, operative temperature, and temperature for all nodes in wich the system has been subdivided;
- the energy requirement to check any possible temperature variation and relative humidity variation above the threshold set for the environmental conditions required.

This model, already has been validated according to experimental results with the prototipe of the mentioned bioclimatic greenhouse /3/. Using this simulation model a simplified methodology has been developed for an easy apporach to calculation.

The process needs, in case,the iteraction of calculations, necessary to evaluate different passive systems, related to different climatic conditions and physical/geometrical characteristichs.

The chosen procedure makes possible to describe various configurations by change in value of each parameters (physical and geometrical).

This casual condiction has generated the idea for using the analytical method in a very simple way.

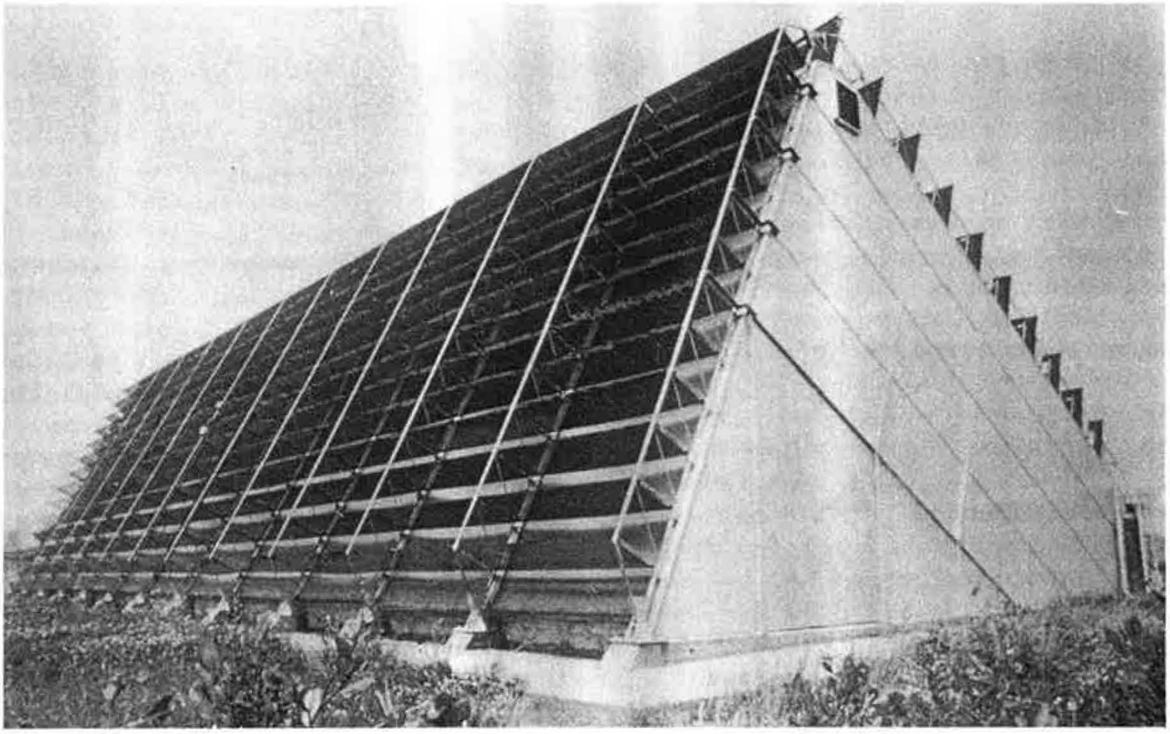

Fig. 1 Prototype of bioclimatic greenhouse.

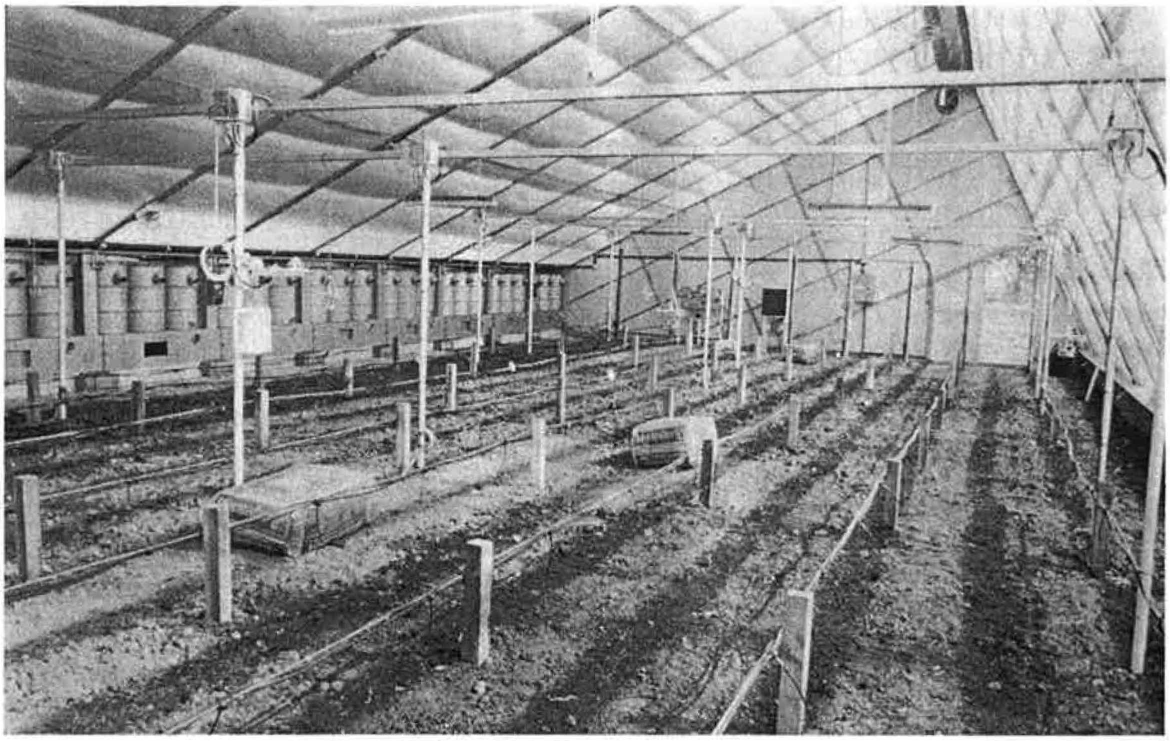

Fig. 2 Interior of bioclimatic greenhouse.

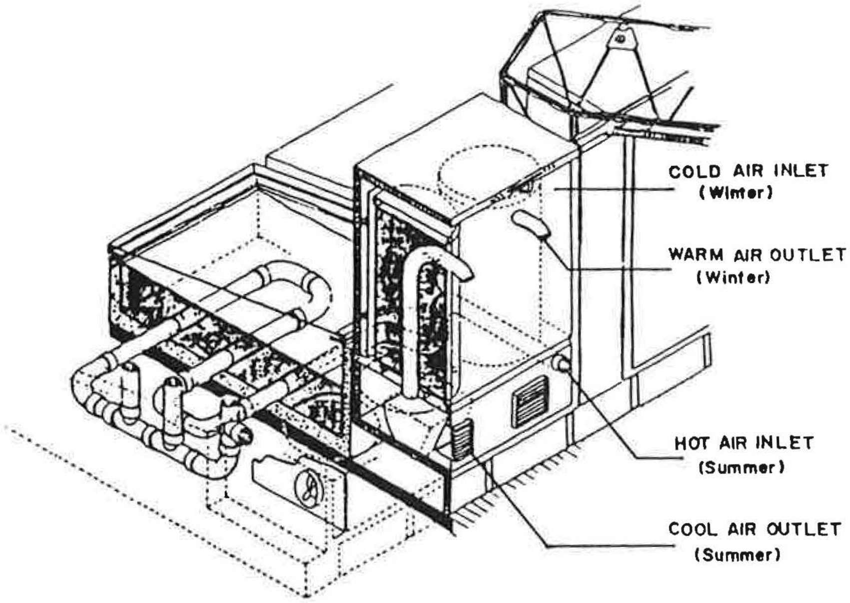

Fig. 3 Bioclimati unit - Air circulation system - Axonometric section.

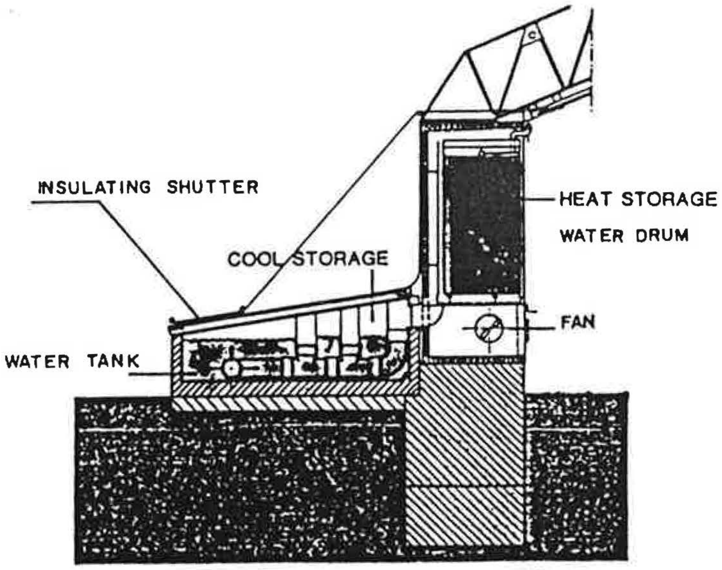

Fig. 4 Bioclimatic unit - Heating and cooling systems - Section

3. THE SEMPLIFIED METHODS

The porpose of this semplified method has been to give to the designers tools that are effective and easy to use, to support their specialized knowledge /4/. Moreover we think to realize "operative graphs", that are diagrams, in wich significant parameters have been put in relationes, on wich the designer operates his choises (fig. 5).
The operative graphs of present many section or sectors, within reference conditions are determinated, for the case in examinetion, to deduce, without the need of computing systems, the parameters that characterize comfort level. The technique is derived from "nomographs" a kind of technical X-Y graphs based on experimental relations, with some modification and adaptation.
To estimate to contribution of passive solar sustems in reduction of energy consuption on buildings, the graphs present design solution of passive solar components and of evolved systems.
The graphs allow the designer, with a few input data, to calculate the solar saving fraction of seasonal heating load related to:
- the ratio between the passive systems area and the heated volume;
- the total heat loss coefficient for volume unit of building.

The calculation is based on medium value of internal heat gain and take in account the degree-days parameter, that is function of base temperature for such internal heat source.
These characteristics compared to other simplified calculation, made the graphs mode easy to fit for various purpouse.
Passive solar graphs are the result of calculation "loops" in wich solar saving fraction value is obtained for many locations, with changes in input parameters.
The used technique is made of statistical regressions related to one complex factor, that resumes the effects of input data; is obtained a curve function approaching the value of annual solar saving fraction for reference locations to the corrispondent value for other locations, if is acted with an appropriate traslation of the curve-function on the graphs. So it's possible to construct an easy to use design tools.
Of course the graphs can assume as input data, more variables, for example is wanted to examine the performance of passive solar system compared to variable heat gains, for the same locations.
We can resume the advantages connected to the use of operative graphs compared to other calculation method in particular concerning:
- the possibility in estimate the validity of one design solution after fixing one o more design parameter:
- speed and easiness in use;
- utilizability for design and verification process; all these advantages are due to the "visibility" of the graphs procedure, and this made the graphs very useful for didactic use.

The graphs should be inserted in technical books, or handbooks, or should be associated to list of building components, in wich performances are shown, or they could be created for particular applications, in climatic regions whose conditions have extreme variations in temperature range, for subject matters.
In a later time the same simulation model has been used for the elaboration of simplified passive cooling calculation method.
It controls the energetic behavior and internal comfort degree for several climatic conditions and various passive cooling systems.
Therefore it has been defined that a number of passive system configurations of which the dimensional, operative (overhangs, variable resistences) and thermal capacity characteristics have been varied.
There are several simulations carried out in different climatic conditions for all configurations.

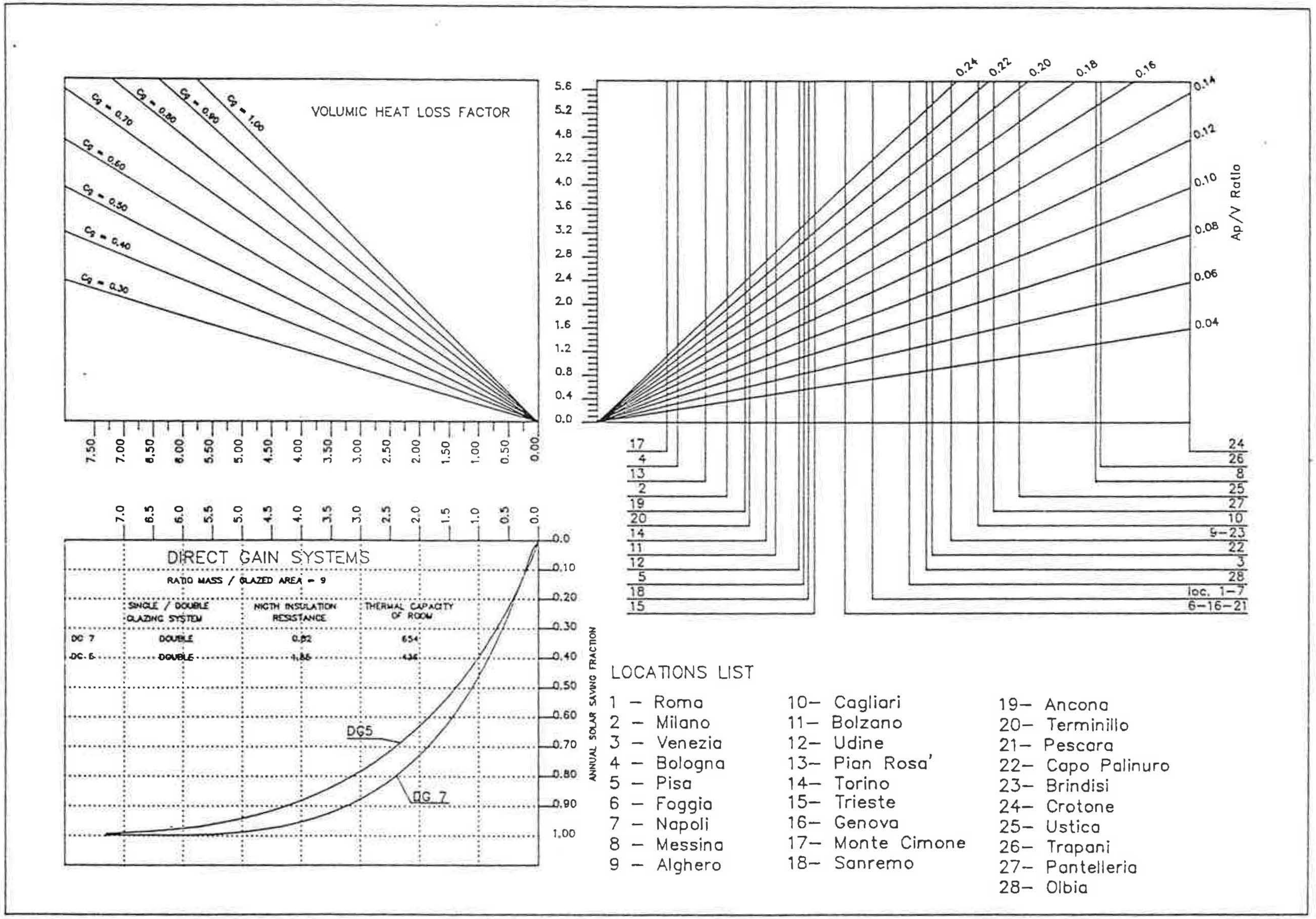

Fig. 5 Operative graph for calculation of annual solar saving fraction.

Throúgh the results of this analysis, the elaboration of a progressive design method for the comfort control is used with regard to the PMV and PPD indices. With this method it shall be possible to individualize the best design solutions for the various climatic conditions. Such design solutions will respond to the options and dimensioning of the passive coolign systems /5/.
Several simulation have been carried out for different systems configuration (passive cooling sistems) through dimensional ratio related to different reference conditions for the occupants (metabolic rate and external work, thermal resistance of clothing, relative interior air velocity).
Actually we are going on - on the ground of the obtained results - to elaborate a simplified design metodology.
In the course of these simulation process the aspect of summer solar radiation protection has made evident as the most important factor for environmental control, expecially when external air temperature rises high value and passive cooling is needed.
A design solution for higrometrical and termal control as been developed during this calculation work. The system (fig. 6) consist of tow separate plane space air, in wich convective air loops occours: the first toword the external side of the building in wich the water is vaporized from nozzles, so the water that evaporates decrease air temperature and increas air density producing a natural convective circulation (fig. 7,8,9).

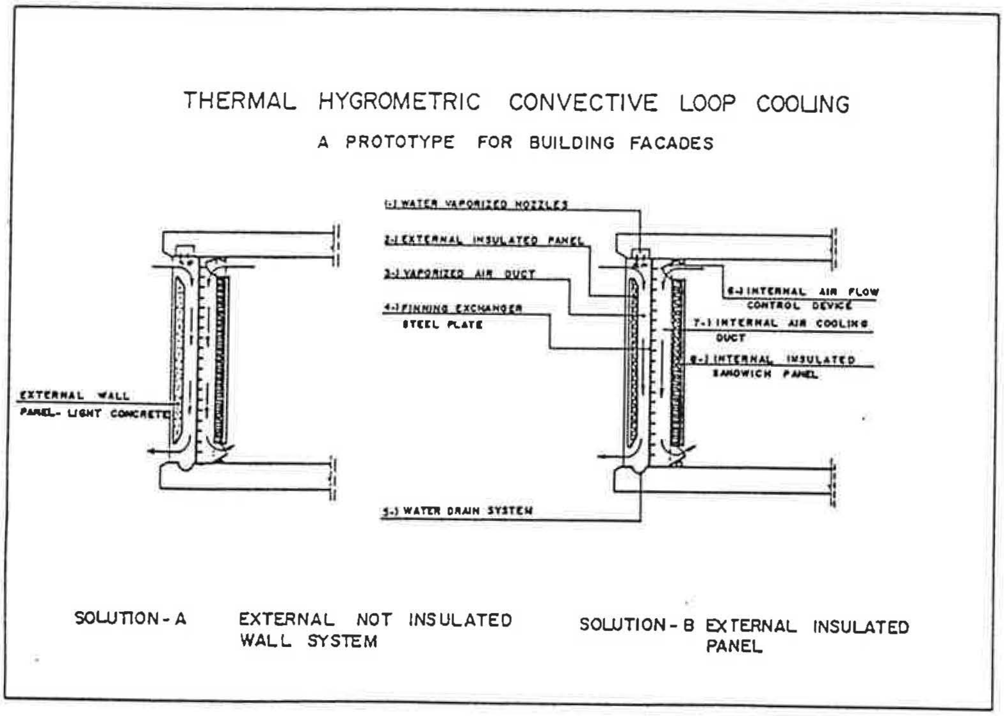

Fig. 6 Passive cooling component.

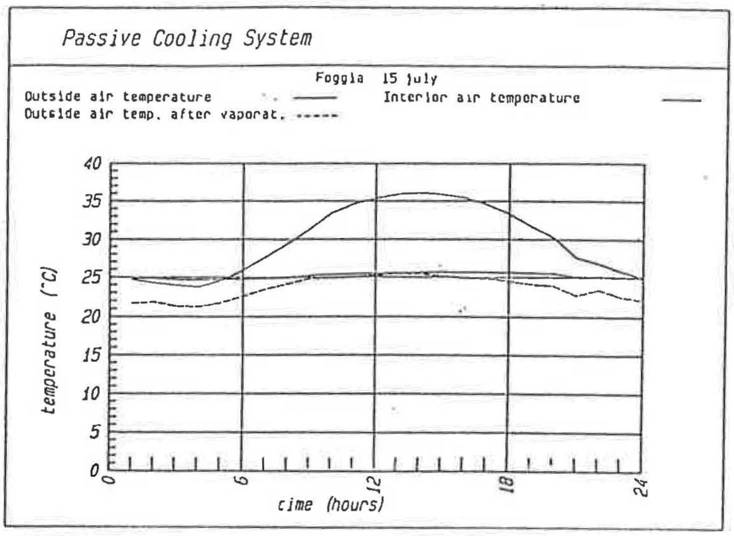

Fig. 7 Fluctiation of air temperature for passive cooling component

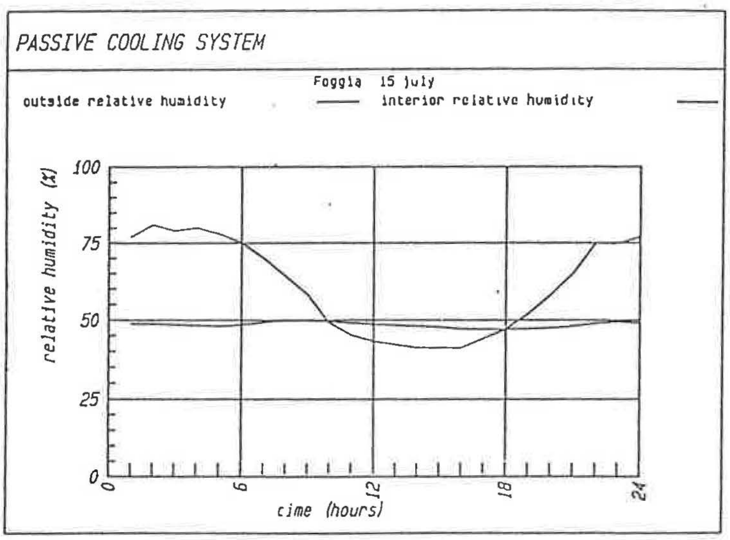

Fig. 8 Fluctiation of relative humidity for passive cooling component

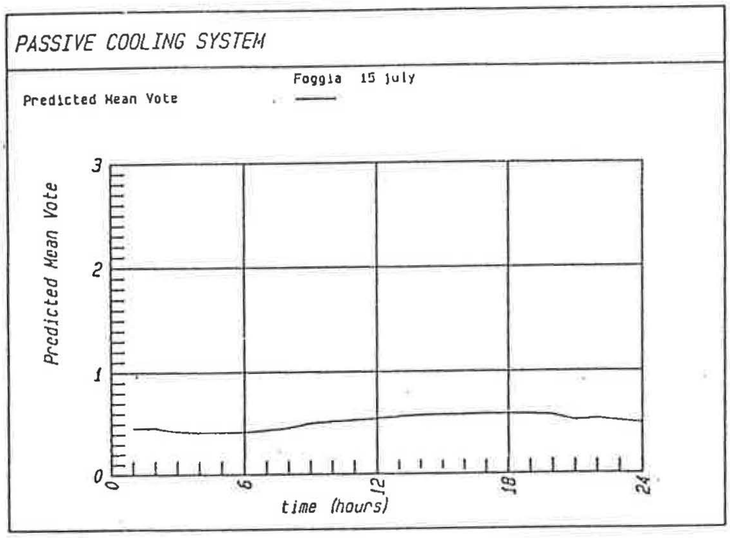

Fig. 9 Fluctiation of Predicted Mean Vote for passive cooling component

The element located as separation between the external and internal space act as a thermal exchanger in wich the internal surface is finning formed. The external air flow cooling this surface and so it causes internal air temperature decrease.
The system is based on a thermocirculation process that renew itself using the effects of natural higrometrical and thermal air properties.
The system doesn't produce internal air humidity increase (fig. 8) because there are separate circuits (the air into of external space in satured).
Calculation results have showed that for reducing PMV (fig. 9) value and internal air temperature (fig. 7), is necessary to insert insulation on the internal side on the first space. This insulation reduces overheating on inside surface, mantaing a lower air temperature value.

4. CONCLUSION

The results of this work conclude that it is possible to make easy tools for design/verification of thermoigrometric and energetic performance for passive solar heating and cooling systems with analytical and simplified types.
For the passive cooling the semplified calculation method now is in progress and there area certain points of interest for the passive cooling proposal.

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