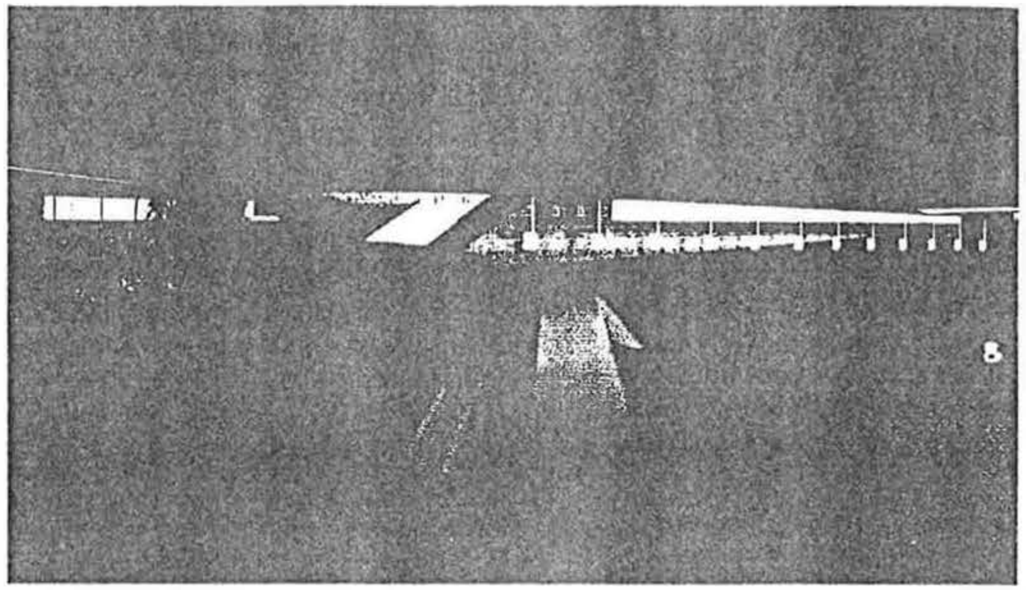

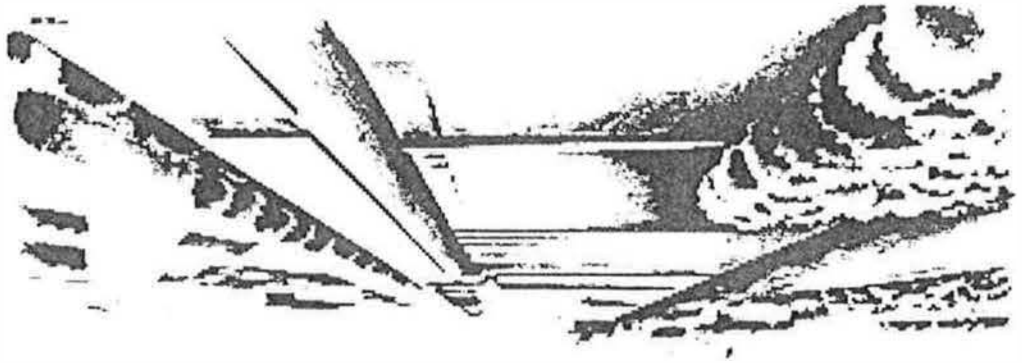

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RENEWABLE ENERGY

SIMULTANEOUS APPLICATION OF DIFFERENT NATURAL COOLING TECHNOLOGIES TO AN EXPERIMENTAL BUILDING

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ABSTRACT

In terms of performance, natural cooling technologies have always been studied by experimentation of single techniques. In order to obtain an improvement in global performance, particularly with regard to comfort, an investigation of the combined utilization of several techniques for the same location has been carried out. This paper gives the results of a series of experiments in which several techniques of natural cooling were applied simultaneously in an experimental building.

KEYWORDS

Natural cooling; ground cooling; controlled ventilation

INTRODUCTION

An experimental building, constructed by a group of researchers of DITEC – Politecnico di Milano, proved to be a valid test-bench for the application of various low energy consumption cooling techniques.
The results of some of the most interesting experiments have already been the subject of various publications (Solaini et al., 1994, 1995, 1996) in which the results obtained for each individual test were described. The techniques adopted were oriented towards different types of plants that could really be applied in existing buildings. The classic natural cooling techniques of controlled mechanical ventilation and ground cooling were experimented in particular, the ground cooling system being obtained by water-ground heat exchangers with various geometrical arrangements (vertical pipes and horizontal pipes) positioned at various depths.
The results of the experiments demonstrated that each of the techniques examined produced different performance characteristics as a function of the ambiental conditions (external temperature, solar radiation, temperature of the ground etc.).
In the summer of 1997, measurement campaigns were carried out in the experimental building, each lasting a week on average, which permitted a comparison of direct performance (the building has two monitored test rooms, with the same characteristics) and an evaluation of the combined effects of the application of several cooling techniques in the same test room.

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The objective of the study was to collect and compare summarized data that permit an evaluation of the combination of the single techniques in ambiental terms (comfort) and in terms of energy (electricity consumption of the mechanical devices).

DESCRIPTION OF THE COOLING SYSTEMS

Two basic techniques were adopted. The first consisted of a simple air extraction system (fan) with a variable speed and, consequently, a variable capacity.

The second cooling system was constituted by water-ground heat exchangers. There were two plant configurations: one with four coils of polyethilene pipes arranged horizontally at different depths; the second with 10 steel pipes, 6 metres long, arranged vertically. In both cases, the pipes were connected by means of headers to the radiant floors of the two rooms. The configuration of the circuit permitted variation of the thermal cooling power.

Both the ventilation and the ground cooling systems were switched on at fixed hours by means of a timer.

MONITORING

A monitoring system was created as well, in order to acquire and record

- the outdoor climatic data;
- the thermohygrometric data inside the building;
- the inlet and outlet air temperatures and the air flow rate for the ventilation system;
- the inlet and outlet water temperatures and the water flow rate for the ground cooling system;
- the temperature values inside the ground at different depths and positions.

The data are acquired and recorded by an HP 75000 data logger and then processed by a computation programme specially developed for this purpose.

DESCRIPTION OF THE EXPERIMENTS

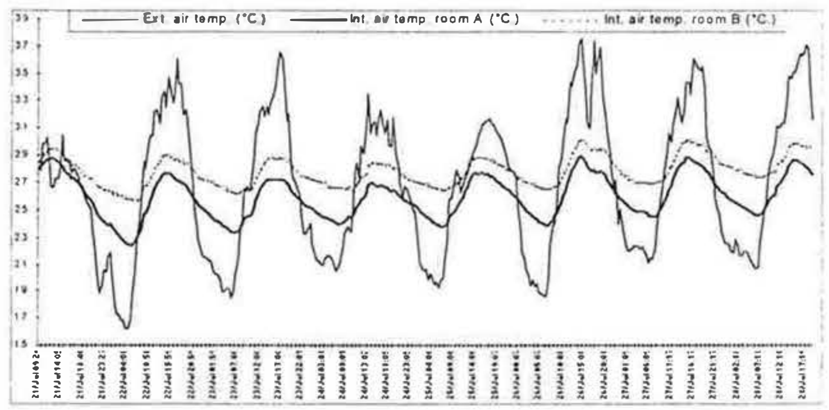
The objective of the first experiments was to evaluate the benefits obtainable from the simultaneous use of ground ventilation and night-time forced ventilation. As preceding experiments had already demonstrated, water-ground heat exchange is extremely effective but the ground rapidly becomes saturated. Consequently, in order to obtain conditions of comfort for the entire summer season, a high ratio of ground volume / cooled volume must be maintained. The first attempt to eliminate this difficulty was to limit the operation of the plant to the day-time period only, disactivating the system during the night (Solaini et al., 1996). The experiment presented here constitutes a further step forward since the flow of water is halved during day-time operation (this further lengthening the time required for the ground to become satured) and forced ventilation at night is activated, thus achieving acceptable levels of comfort (even though slightly worse than with continuous operation and maximum power of the ground cooling system).

To evaluate the contribution provided by the night-time forced ventilation, the ambiental and energy data in two identical test rooms were collected, one cooled by day-time ground-cooling + natural ventilation + night-time forced ventilation (room A) and the other solely by day-time ground-cooling + natural ventilation (room B). Obviously, both the rate-of-flow of the water in the ground-cooling system and the natural ventilation conditions were identical in both rooms. The day-time period extended from 8 a. m. to 8 p. m. and the night-time period from 8 p. m. to 8 a. m. The forced ventilation corresponded to 15 air changes per hour. The experiments were carried out using both the horizontal pipe installation and the vertical type configuration, with the same water mass flow rate (210 kg/h for each room). The experiments were carried out, respectively, in the periods 21-28 July 1997 and 12-18 August 1997.

RESULTS AND CONCLUSIONS

The performances of the various combinations of natural cooling systems were evaluated in terms of ambiental comfort and energy efficiency. Figures 1 and 2 show the temperature curves and the relative PMV of the two experiments, while Table 1 gives the corresponding average values, in terms of ambiental and energy data.

a)



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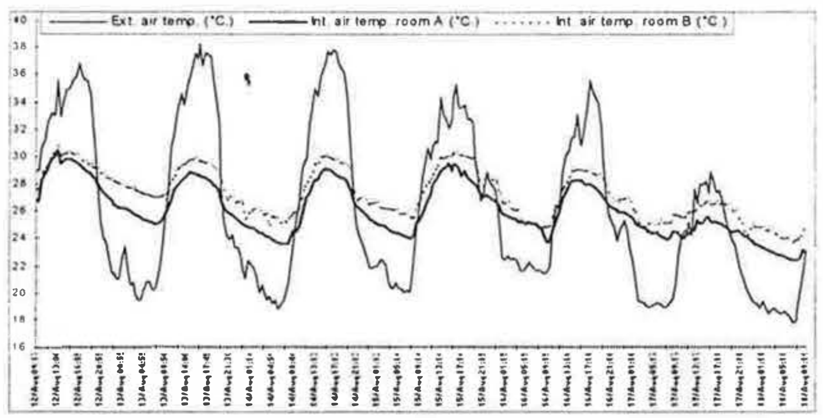
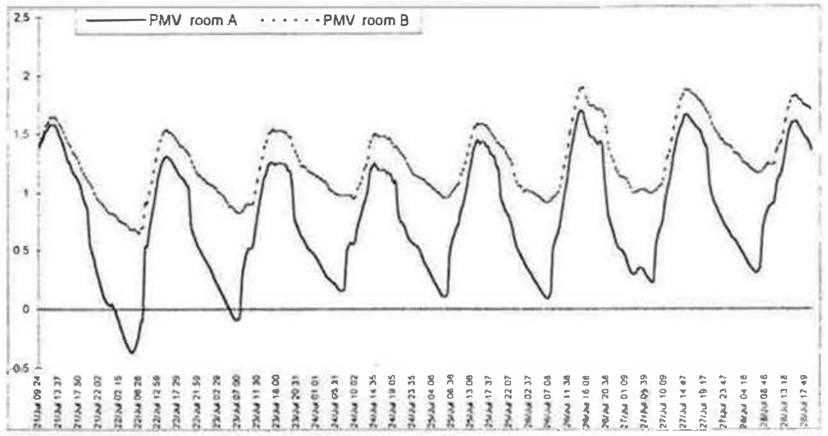


Fig. 1. Temperatures behaviour : a) horizontal pipes, b) vertical pipes

a)



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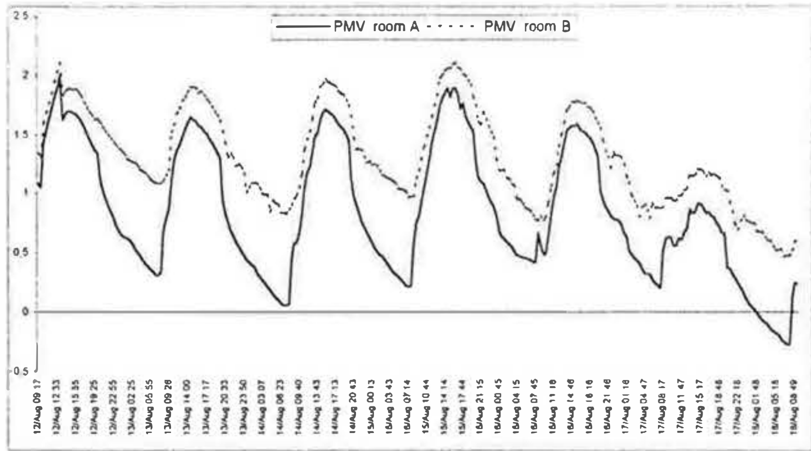

Fig. 2 PMV behaviour: a) horizontal pipes, b) vertical pipes

Table. 1 Ambiental and energy data: a) horizontal pipes, b)vertical pipes

a)

Period	Av. ext. air temp. (°C)	Average int.air temp. (°C)		Average mean radiant temp. (°C)		Average relative humidity (%)		Average PMV	
		room A	room B	room A	room B	room A	room B	room A	room B
Day + Night	26.8	25.9	27.8	26.3	27.4	56.8	48.2	0.66	1.26
Day	30.7	26.9	28.4	27.1	28.0	54.8	47.5		
Night	22.5	24.9	27.1	25.3	26.8	59.1	48.9		

b)

Period	Av. ext. air temp. (°C)	Average int.air temp (°C)		Average mean radiant temp (°C)		Average relative humidity (%)		Average PMV	
		room A	room B	room A	room B	room A	room B	room A	room B
Day + Night	26.2	26.1	27.3	26.4	28.3	50.9	43.5	0.75	1.31
Day	30.8	27.2	28.3	27.3	28.9	49.3	42.7		
Night	21.8	25.0	26.2	25.5	27.6	52.4	45.2		

a)

Period	Av. ext. air temp. (°C)	Extracted heat (Wh)		Electric energy consumption (Wh)		Average COP	
		room A	room B	room A	room B	room A	room B
Day + Night	26.8	52417	31785	10540	7012	6.1	5.2
Day	30.7	water 25836	water 31785	water 7012	water 7012	water 4.6	water 5.2
Night	22.5	air 26580		air 3528		air 7.6	

b)

Period	Av. ext. air temp (°C)	Extracted heat (Wh)		Electric energy consumption (Wh)		Average COP	
		room A	room B	room A	room B	room A	room B
Day + Night	26.2	45979	27085	8428	5362	5.4	5.0
Day	30.8	water 22836	water 27085	water 5362	water 5362	water 4.2	water 5.0
Night	21.8	air 23143		air 3066		air 8.0	

It is immediately obvious that similar results have been obtained both with the horizontal pipes system and the vertical pipes one, so that a double experimental validation is available; moreover, the combination of day-time ground-cooling and night-time forced ventilation not only produces lower operating temperatures and lower PMV but also increases the coefficient of energy performance (COP), defined as the ratio between heat extracted and electricity consumed for the operation of the water circulation pump and the fan.
It is interesting to compare these results and those obtained in a previous experiment (from 29 July to 5 August 1994) obtained with similar climatic conditions in the test rooms, activating a ground-cooling system (horizontal pipes) in one room and a maximum flow of water for 24 hours a day and leaving the other room without any system of cooling.

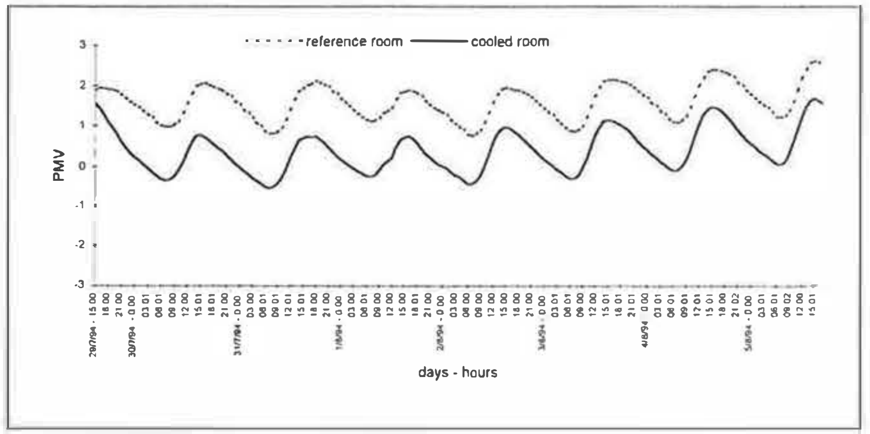

Fig. 3. PMV calculated for the cooled and reference room in 1994 (horizontal pipes).

As can be seen, the results obtained from the experiments are similar for the cooler rooms. This means that the system of day-time ground-cooling with half the flow of water + night time forced ventilation produces almost the same effects as the system of continuous operation of the ground-cooling system with maximum flow. However, as has already been said, in the first case, ground saturation is slower.

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RENEWABLE ENERGY

TRADITIONAL ARCHITECTURE, BUILDING MATERIALS AND APPROPRIATE MODERNITY IN CHILEAN CITIES.

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ABSTRACT

This paper discusses and analyses new buildings, inspired by traditional models of architecture, that propose energy savings and the use of local material revalidating the urban image of Chilean cities.
However, as this paper demonstrates this adoption of traditional models, with their subsequent emphasis in ecological measures, such adoption is still intuitive and not a major principle of design. Therefore, isolated examples of modern buildings deal in an appropriate manner with their climatic and geographical context.
This kind of urban development contradicts the image of the country, which has been perceived by the international community as one of the most emergent economies. Consequently, central and local governments know that they have to aim a more environmental development in order to balance an explosive, and sometimes uncontrolled, way of building our cities.
The conclusions stress the importance of creating common patterns of design for achieving better performances of buildings, owing to the fact that traditional models have been inherited and already exist as valid references. Especially, if Chile is to pursue both economical and sustainable development.

KEYWORDS

Tradition, patterns of design, climatic effects, geographical context, local/recyclable materials, built form, appropriate modernity.

THE IMPORTANCE OF LOCAL CONTEXTS

Prevailing Economic and Geographical Contexts

Chile is considered a wealthy nation and recognised as one of the most dynamic process of development. Its economy is one of the fastest growing in the southern hemisphere. The country's economy "has earned it the epithet 'Puma of South America' because it has grown almost 7% for each of the past nine years. In the early 1990s, construction output grew 10% a year" (Bill, 1995). This process is also reflected in new schemes demanded by this dynamic market, particularly in the areas where this flurry of economic development has taken place showing a boom in construction activity.
The weather in the country, approximately 4,500 Km in length, is influenced by the Pacific Ocean along its coasts, and reveals surprising and contrasting scenarios with different architectural expressions that depend on a variety of geographical contexts.

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