As environmental development plays an important role in architecture, the concept of recycled materials and embodied energy has defined a new attitude when designing new buildings or converting existing ones. Besides, the geographical isolation of many areas of the country, to certain extent, has allowed a new local architecture which remains based on local materials, whilst improving quality of life with efficient ventilation and heating. Subsequently, contemporary approaches have developed a wider range of systems, such as breathing walls or much better sealed windows, that did not exist in the past.
The use of timber, for instance, has encouraged the government to set up plans for forest management and also to control the quality of the soft woods that are used more often as a renewable resource.

CONCLUSIONS

Along Chile it is possible to find lively constructive answers to local needs, based on existing architectural models, but reshaped to modern life. The social and economical context has changed through the years requiring new solutions from the building sector. What has not changed is the opportunity to retain the local identity by the appropriate use of local and renewable materials as it has been inspired by this so called 'appropriate modernity'.
This approach has reinforced an existing architectural image and integrated new buildings into the urban fabric, enhancing the urban memory of towns and the perception of their inhabitants.

The concept of embodied energy has been well understood in the building process using locally produced materials and avoiding the higher transport costs of bringing other imported ones. Advantageously, these traditional materials are not only related to this particular context, but have also provided a better answer to the climatic conditions. The use of local materials and the introduction of recycled elements has also allowed the negative environmental impact of buildings to be diminished.

This suggest that better examples will appear in time. In fact, economic wealth is providing the arena for designing buildings with better standards of construction. This has permitted the adaptation of traditional methods of construction to new technologies, but using the same available local resources such as timber or shingles in the South.

This series of urban, architectural and construction principles are the main arguments in the conclusion that these examples represent a right approach to sustainable buildings, because all of them are based on a wide range of local traditions. As argued in this paper, some of them go beyond the architectural or urban scale and are well integrated into the geographical scale.

Therefore, it is rational to advance an idea of 'sustainable design' and to have an appropriate image of architecture. Consequently, simple operations related to the design and construction of spaces where we live, can transform the way we interact with our built environment, thus producing this necessary change on the global scale and bringing the necessary identity to modern architecture and its future inhabitants.

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RENEWABLE ENERGY

VENTILATED-SOLAR ROOF AIR FLOW AND HEAT TRANSFER INVESTIGATION

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ABSTRACT

The governing parameters for flows generated by heat transfer from solar cell modules to air gaps are discussed. Experimental results are presented from measurements in mock-ups of ventilated facades and roofs. The heat transmitted from the solar cells to the air have been mimicked by the use of heating foils. The inclination angle of the roof, position of solar cell module and the height to width ratio (aspect ratio) have been varied. The bulk properties as the air flow rate in the air gap, local temperatures and velocities have been measured. Results of importance for design of hybrid systems and cooling of solar cells have been obtained.

KEYWORDS

Photovoltaic modules, air gap, hybrid systems, experimental studies, physical model

INTRODUCTION

The heat supplied to the air generates an air flow rate, Q, in the air gap with a cross sectional area $A = wd$. For convenience the total amount of heat, q, supplied to the air is expressed as the specific buoyancy flux $B = g\beta q / \rho C$. An important geometrical factor is the aspect ratio H/d. The distance, y_s, from the eaves to the module governs the length of the heated air column. This is expressed by the shape factor α.

$$\alpha = [(1 - L/2H) - y_s / H] \tag{1}$$

where, L, is the length of the module. The theoretical maximum of the shape factor is 1 (all heat input concentrated in a "point" located at the bottom ($y_s = 0$). For uniform heating along the whole height, H, the shape factor is equal to 0.5. The effect of the roof angle, ϕ, is a reduction of the effective acceleration of gravity to, $g\ Sin\phi$, The friction is expressed by the friction factor, λ. Losses at the entrance are denoted by, k_{entr}. Solution of the momentum

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equation, assuming turbulent flow, uniform velocity and temperature profiles gives the flow average velocity, $U = Q/A$.

$$U = \left(\frac{\alpha B Sin\phi}{\psi}\right)^{1/3} \tag{2}$$

The temperature rise $\Delta T = T_o - T_i = B/(UAg\beta)$

$$\Delta T = \frac{1}{Ag\beta}\frac{B^{2/3}}{(\frac{\alpha Sin\phi}{\psi})^{1/3}} \tag{3}$$

where $\psi = \frac{wd}{H}[\lambda\frac{H}{d} + \frac{1}{2}(1 + k_{entr})]$

The equations can be simplified for some special cases (Table 1).

Table 1 Theoretical expressions (turbulent flow) for some conditions

Condition	ψ	Velocity	Temperature rise
Friction dominates over entrance losses H/d→∞	$w\lambda$	$U = (\frac{\alpha\frac{B}{w}Sin\phi}{\lambda})^{1/3}$	$\frac{1}{Ag\beta}\frac{B^{2/3}}{(\frac{\alpha Sin\phi}{w\lambda})^{1/3}}$
No losses $\lambda = k_{entr}$	$\frac{wd}{H}$	$U = (\frac{\alpha\frac{B}{w}\frac{H}{d}Sin\phi}{0.5})^{1/3}$	$\frac{1}{Ag\beta}\frac{B^{2/3}}{(\frac{\alpha Sin\phi}{0.5w\frac{d}{H}})^{1/3}}$

For laminar flow there is no simple analytical solution to the general momentum equation. However, on the same conditions as in Table 1 and laminar flow, both velocity and temperature rise are proportional to $B^{1/2}$.

EXPERIMENTS

The experiments were undertaken with two building elements. Element a) with the height H = 6.5 m and where the thickness, d, of the air gap was varied (d= 0.23, 0.115 and 0.06 m). This element was only used to explore the effect of the aspect ratio. Element b) is shown in Fig. 1, had the length H = 5m and air gap d = 5 cm. Both building elements had thick insulation to ensure adiabatic conditions. Earlier studies on flow and heat transfer on facades were reported in Moshfegh and Sandberg (1996) and Sandberg and Moshfegh (1996).

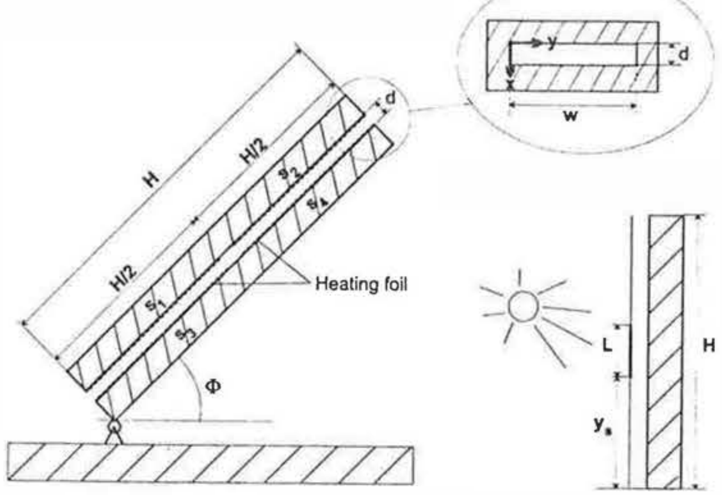

Fig. 1. *Left*. Sketch of experimental set-up. *Right* Notation for shape factor

Flow Rates

The flow rate was measured by tracer gas technique (constant flow technique)

The effect of the change of the location from the upper to the lower part of the air gap
The effect of the change in position of solar modules from the upper side of the air gap (Position S1 or S2) to the lower side (Position S3 or S4) is only marginal for all inclination angles $\phi \leq 70°$. It is only noticeable when there is a shift in position from S2 to S4, on average the flow rate increases by 13 %.

The effect of the location (shape factor) of the solar modules
When shifting the position of the module from S1 (α = 0.75) to S2 (α = 0.25) there is a pronounced change in the flow rate. With an exponent equal to 1/3 the expected change is $3^{1/3} \approx 1.44$ and with the exponent equal to 0.5 the expected change is $3^{1/2} \approx 1.73$.

Table 2. The increase in flow rate by changing the position of the module from S2 to S1

Inclination angle	40 [W/m^2]	120 [W/m^2]
25°	1.51	1.61
45°	1.48	1.94
70°	1.83	1.66
90°	1.72	1.76
Average	1.64	1.74

The difference in flow rate is substantial when changing the position of the solar cell module with respect to the distance from the eaves. Therefore the shape factor is an important parameter to be considered in the design of building integrated solar cell modules

The effect of the change of shape factor

The change in velocity when changing the aspect ratio follows a power law relation, $u \approx (H / d)^{\gamma}$ with an exponent γ ;50 W/m^2 (γ= 0.44), 100 W/m^2 (γ=0.46), 200 W/m^2 (γ=0.32 and 300 W/m^2 (γ= 0.25).

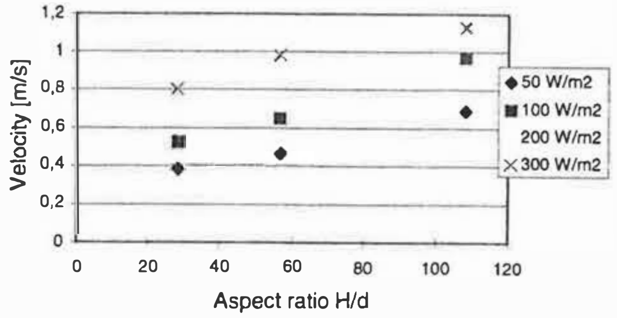

Fig. 2. Flow average velocity as a function of aspect ratio

The change in velocity when changing the aspect ratio follows a power law relation, $u \approx (H / d)^{\gamma}$ with an exponent γ ;50 W/m^2 (γ= 0.44), 100 W/m^2 (γ=0.46), 200 W/m^2 (γ=0.32 and 300 W/m^2 (γ= 0.25).

Velocity Profiles

The velocity profile has been recorded with a thermistor anemometer.

The velocity profile is non-uniform and the highest velocity does not always occur at the heated side which indicates that there may be a complicated air flow pattern. The net effect will be a non-uniform cooling of the module which will decrease the output from the module. The fact that the velocity profiles become more non-uniform with increasing heat input indicates that the unsymmetry is inherent in the flow itself and not caused by external disturbances. An additional support for this is that when the slope is increased at constant input heat flux from ϕ= 30° to ϕ= 90° (i.e. the flow rate increases) the profile becomes more irregular.

Temperature Profiles

Fig. 4. shows temperature profiles recorded across the air gap at the height H/2. For both cases, i.e. the solar modules located on the upper or the lower part of the roof, there is a U-shaped profile for all inclination angles. This is due to the fact that the heat is transferred via

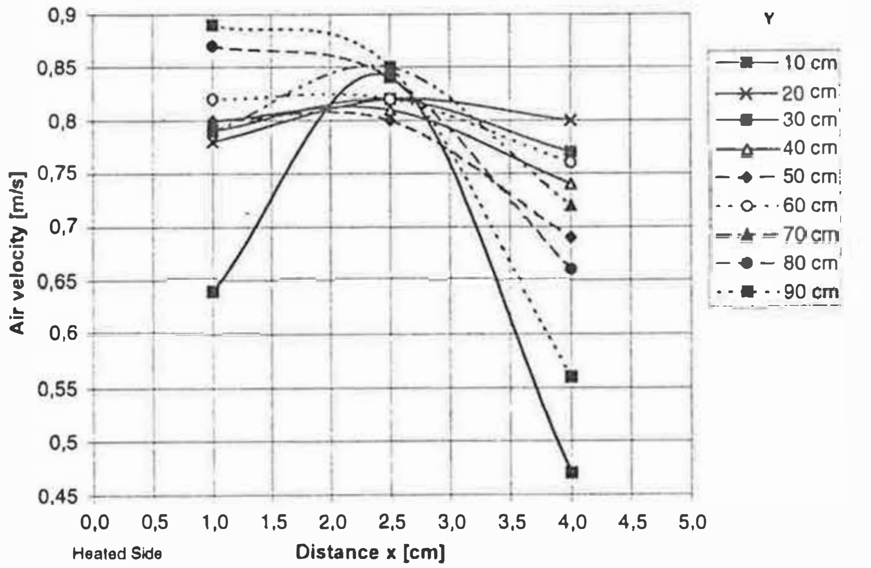

Fig. 3. Velocity distribution (q = 400 W, ϕ=90) at the top of the "roof".

radiation from the heated side to unheated side and provides a higher surface temperature than the air flowing close to the unheated surface. For both cases, the temperature of the heated side and the bulk temperature of the air increases (see Table 3) by a decreased inclination angle, this can be explained by less cooling due to a decrease in flow rate.

It is also important to mention that the bulk temperature at the upper located solar module is higher than at the lower one, because the lower density air is above the higher density air and no side-to side convection occurs at the upper located solar module.

The air temperature at 1.1 cm distance from the heated side for the case where the module located at the upper part of the roof is measured at different inclination angles and the results show an almost linear relation to the angle, the air temperature increases by a decreased angle. While for the case where the module is located at the lower part, the air temperature at 0.5 cm

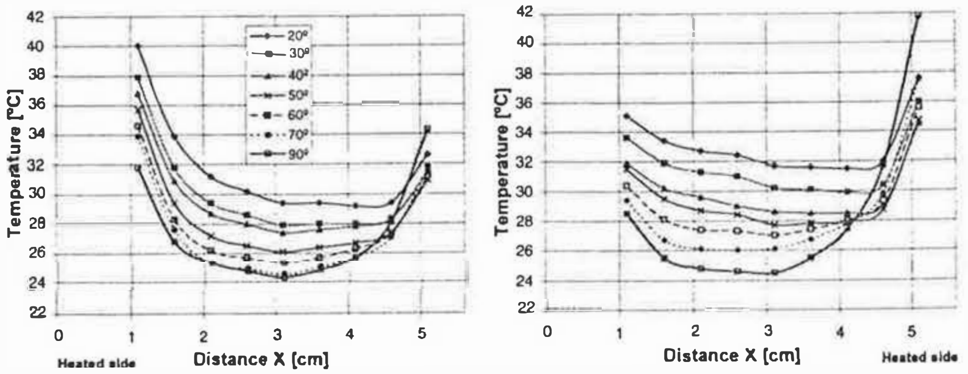

Fig. 4. Recorded air temperature profile as a function of the inclination angle

Table .3. Bulk temperature at $H/2$ = 2.5 m for q = 800 W

	Inclination angle						
Case	20°	30°	40°	50°	60°	70°	90°
Heated sections S1 and S2	31.7	30.1	29.7	28.5	27.8	27.3	27.3
Heated sections S3 and S4	33.1	31.6	30.0	29.4	28.9	28.5	28.2

distance from the heated side behaves differently from the previous case. First the air temperature decreases rapidly with a decreasing angle and then the changes are slower.

RESULTS

Theoretically the relation between the total heat input, q, and the flowrate, Q, in the air gap is a power law relation $Q \sim q^{\gamma}$ with γ equal to 1/2 (laminar flow) or 1/3 (turbulent flow). To great extent the recorded values lie within this interval.

When changing the inclination angle, ϕ, the change in flow rate follows the theoretical, $Sin\ \phi$, relation. The effect of a shift in position of the solar cell module along the facade or roof is close to the theoretical shape factor and therefore an important parameter. For an aspect ratio in the range 20 to 110 the relation between a change in the aspect ratio and the change in flow rate follows a power law relation with an exponent starting at 0.44, for the lower heat fluxes, and decreases to 0.25.

For a roof at different inclination angles, shifting the position of the module from the upper side to the lower side of the air gap effects the temperature of the module and the bulk temperature of the air, but not much the generated flow rate. When positioned on the lower side, the side-to side convection becomes more important for the heat transfer and therefore the temperature of the module decreases rapidly with a decreasing angle and then the changes are slower while for module positioned on the upper side an almost linear relation between the air temperature and the angle is observed, the air temperature increases by a decreased angle.

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ENERGY EFFICIENT ROOM AIR DISTRIBUTION

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ABSTRACT

An environmental chamber has been used to compare the effectiveness of mixing and displacement ventilation in terms of heat and contaminant removal. Results are presented for CFD simulations of the air movement in the chamber and for measurements using a heated mannequin with displacement ventilation. The CFD simulations and the measurements suggest that displacement ventilation is more energy efficient than a mixing system.

KEYWORDS

Ventilation; room air movement; indoor air quality; ventilation effectiveness; thermal comfort.

INTRODUCTION

As the standard of building insulation has been increasing in the last two decades, the energy requirement for ventilation is becoming, in most cases, larger than the building fabric's heat loss/gain and internal load gains. Another factor which has contributed to the increase in ventilation rate is the increase in indoor pollutants which has resulted into the specification of larger outdoor air flow rates to maintain acceptable indoor pollution concentrations. Although there are various heat recovery methods which can be applied to reduce the impact of high ventilation rates on the energy consumption for a building, e.g. AIVC TN 45 (1994), the method of distributing the air also has some effect not only on the energy consumption but also on the indoor air quality, see Awbi and Gan (1993).

In room air distribution, there are usually two methods of supplying the air: either mixing ventilation (dilution) or displacement ventilation. In mixing ventilation, air is normally supplied at high level over the ceiling which is then deflected down into the occupied zone by the opposite walls thus causing a mixing of the air jet with room air. In displacement ventilation, the air is supplied at low level, usually over the floor, and then rises up due to buoyancy before it is extracted at high level.

In this paper the effect of the method of distributing the air in the space on the air quality, thermal comfort in the form of PMV/PPD and other thermal and air quality parameters is discussed. The impact of these parameters on the energy requirement for room ventilation is also discussed. The study is based on simulating the air movement, heat and contaminant distribution in an environmental chamber

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