DYNAMIC INSULATION ENVELOPE: ENERGY SAVING AND THERMAL COMFORT

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0 INTRODUCTION

The poster presented in this Conference synthetizes last years research works on dynamic insulation wall systems, developped within cooperation between Politecnico di Milano - DISET and the industrial partner Centro Sviluppo Settori di Impiego, with a C.N.R. grant[2].The ventilation of vertical cavities in envelope systems has been demonstrated to be useful not only for energy saving, but also for thermal comfort (in winter and summer). The reduction of radiative exchange between internal surfaces of the enclosure and users is significative especially for hospitals or offices, where air conditioning is used and there are particular comfort exigences.

The application of dynamic insulation concepts appears to be particularly performing in the case of glazed enclosures. After bibliographic and theoretical studies different functional models of dynamic insulation systems has been studied and a prototype of dynamic insulation window has been submitted to laboratory testing .

The chief aims of the laboratory testing where:

- Thermal insulation: evaluation of energy parameters, at various air flows in the cavity
- Thermal comfort: measurements of internal superficial temperatures on the window and influence on the internal comfort parameters
- Cavity superficial condensation conditions
- Comparison between theoretical results and mathematical models

These experiments gave us the opportunity to optimize a prototype , which is now beeing tested in outdoor Passys test cells in the Joint Research Centre of Ispra(VA).

This report aims at the presentation of performance propensity of the dynamic insulation system through the analysis of functional models and the result of tests.

1 DYNAMIC INSULATION SYSTEMS: DEFINITION OF FUNCTIONAL MODELS

In the tradition the presence of an air gap in a vertical wall has the chief function to contribute to water tightness, stopping the capillarity transfer of rain water; in a new approach the integration of such cavities in an enclosure may have further functions. Air gaps may have a function to get solar energy as indirect "solar air heaters" [ref.12] or to activate natural ventilation as "solar chimneys" .The functioning of such systems is oriented to the control entering energy flows: in the first case to maximize the solar gains in winter conditions, in the second case to minimize them in summer conditions.It's to say that usually tha mass transfer in the air gap involves only one of the environments separeted by the enclosure: in "solar chimney" (fig. 1.a) air flows from the outdoor environment, which out goes again, after having passed through the gap, while in "solar air heater walls" (fig. 1.b) indoor air enters again inside, after a positive variation of its enthalpic content. Beside these two functional models (indoor-

indoor and outdoor-outdoor) we can define two other models which present a passage in the gap of outdoor air inwards and viceversa [ref.3] (fig. 1.c, 1.d).Of course the physical constitution of internal and external layers will influence the performance optimization of the system.

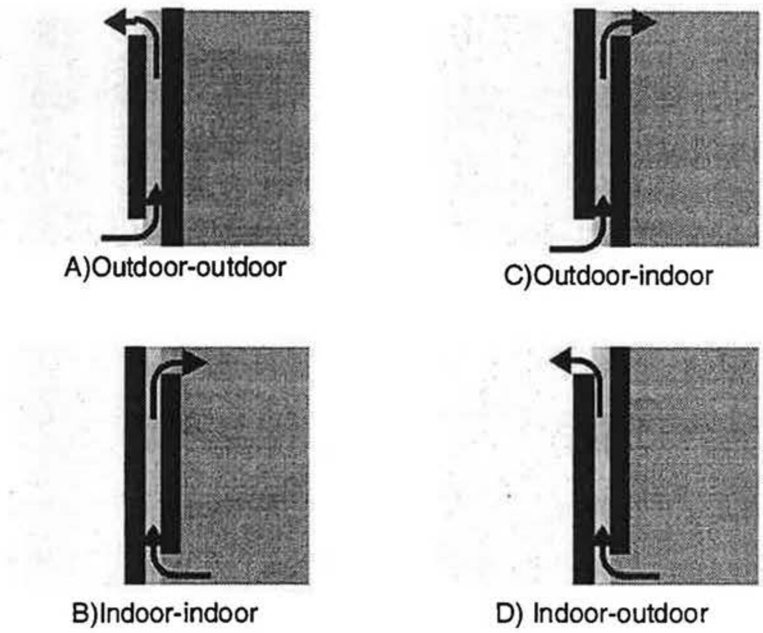

Figure 1 Elementary functional models of dynamic insulation envelopes

To apply these elementary models to real building systems it's possible to define different hypothesis of HVAC plant integration: we present here the our design hypothesis .(fig. 2)

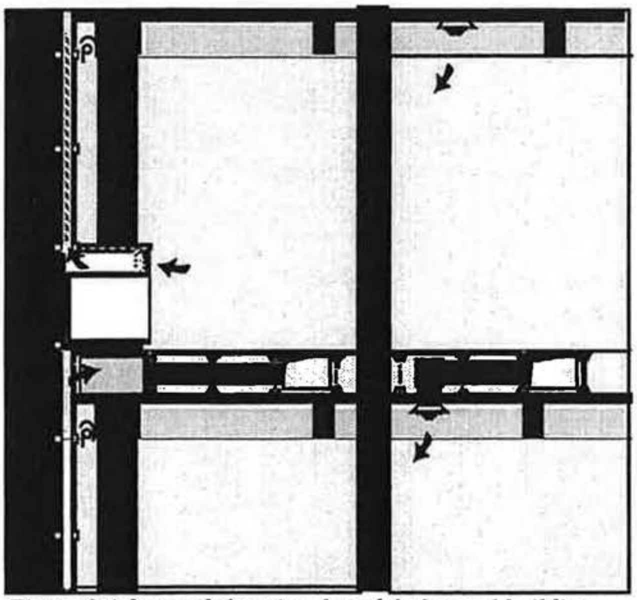

Figure 2 Advanced functional models for real building application of indoor-outdoor model

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2 PERFORMANCE PROPENSITY EVALUATION OF DYNAMIC INSULATION ENVELOPE SYSTEMS FOR BASIC REQUIREMENTS

In the analysis of elementary functional models we'll refer to the following basic requirements:

1 winter thermal comfort

2 summer thermal comfort

3 air quality (ventilation control, air changes)

4 energy saving.

These requirements can be related to the following performances:

convective comfort control

radiative comfort control

energy fluxes control

indoor ventilation control

To evaluate the performance propensity related to basic requirements we can compare performances for the analyzed dynamic insulation systems with the traditional static systems.In other words one can evaluate (always in terms of propensity) if the model improves or worsens the answer to the identified requirements, in comparison the so-called static configuration, then, on the basis of these evaluation we can find a better or worse performance propensity.

In figures 3, 4 are presented the functional patterns of the dynamic insulation models type 1.d, which we considered for experimental prototype, with respective performance propensity evaluation.

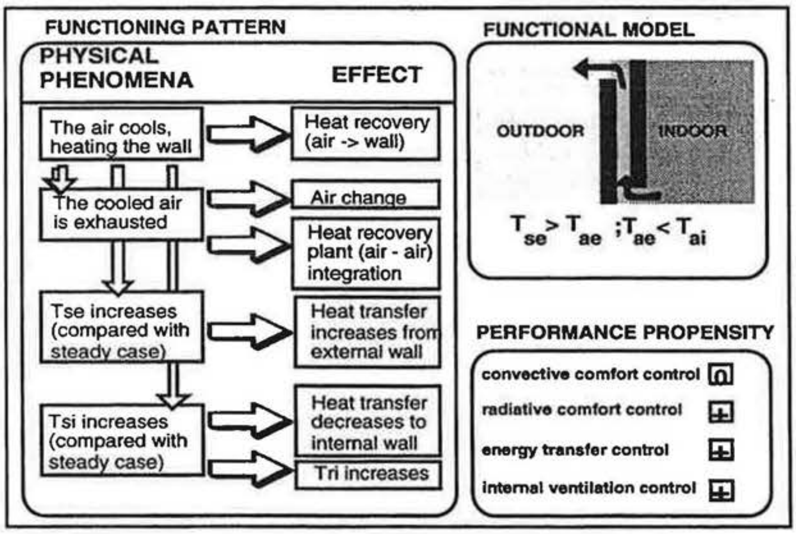

Fig. 3 Functional patterns of dynamic insulation model type 1.d in winter conditions

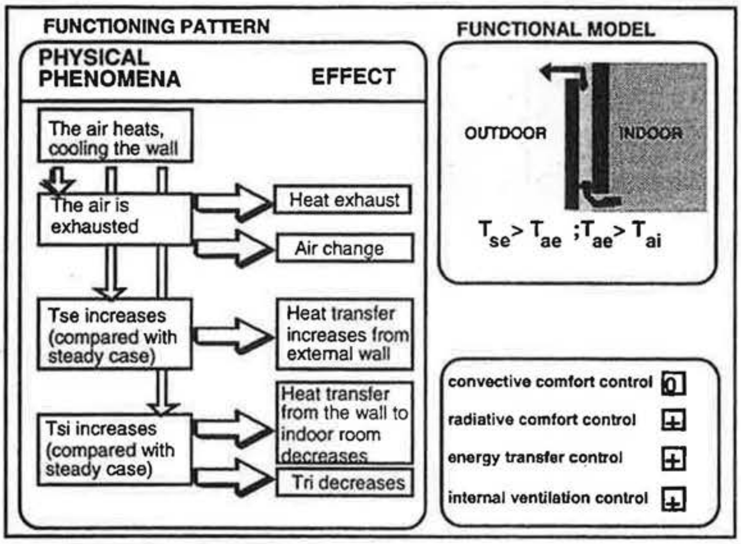

Fig. 4 Functional patterns of dynamic insulation model type 1.d in summer conditions

3 FIRST EXPERIMENTAL RESULTS

Windows have been evaluated under conditions which simulate steady functioning of building components.

Each specimen has been tested for any combination of the following physical conditions:

Internal air temperature = 20 °C

External air temperature= 0 °C

Input cavity air temperature = 20 °C

Cavity air relative humidity = 50; 80 %

Cavity air flow = 0; 100; 200; 300 m^3/h

In figures 5, 6 has been reported a graphical presentation of surface temperature profiles versus gap air flow.

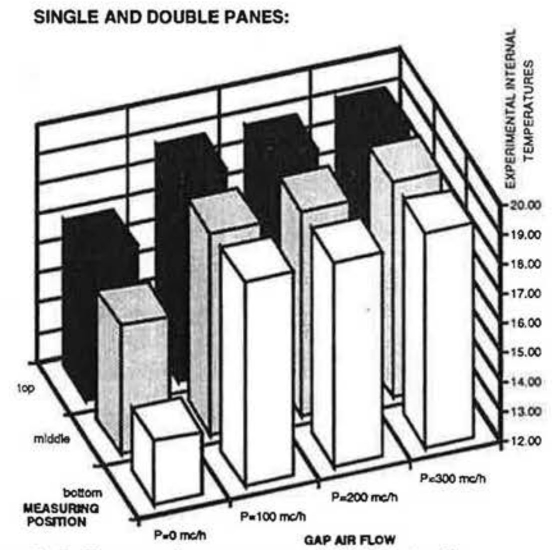

Figure 5: Indoor surface temperatures for single and double panes dynamic insulation window.

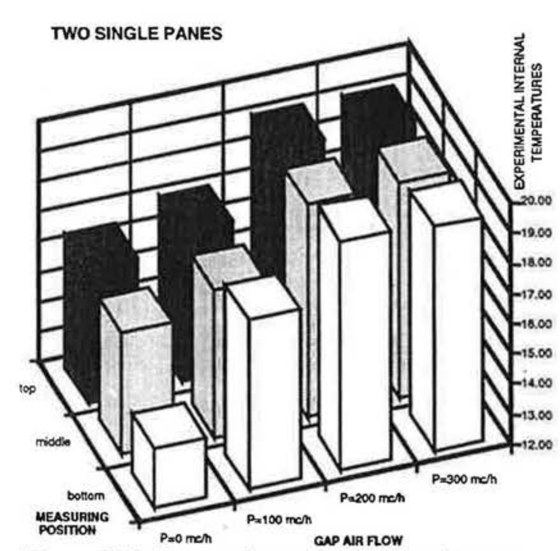

Figure 96 Indoor surface temperatures for two single panes dynamic insulation window

Of course in the case of a two single panes window will be necessary to use higher air flow rate to reach the same performances as for insulated glazing windows.

From these data, we can assume that the temperature differences at various position levels measured for the static case are almost cancelled in dynamic insulation systems.

To express research results we used mainly two kind of synthetic parameters.

The first is what we called *transmittance reduction coefficient* and we indicate with the Greek letter χ.

It evaluates both comfort and energy saving performance of the element and gives an information on how much internal surface temperature arises and heat flux from indoor decreases with air flow:

$$\chi = Q_i/Q_i^\circ = \Delta T_{si}/\Delta T_{si}^\circ$$

Energy transfer versus air is evaluated with h defined as the ratio between effective energy gain in air gap mass transfer and enthalpy difference between internal and external air. It gives informations on how much air temperature decreases, passing through the cavity and, being very similar to an air exchanger efficiency parameter , is called "air gap" or "equivalent exchanger" efficiency:

$$\eta = \Delta T_{int}/\Delta T_{i-e}$$

The values of the parameters obtained for the two window tests are compared with theoretical results obtained by mathematical modelling of the cavity in fig.7 and 8.

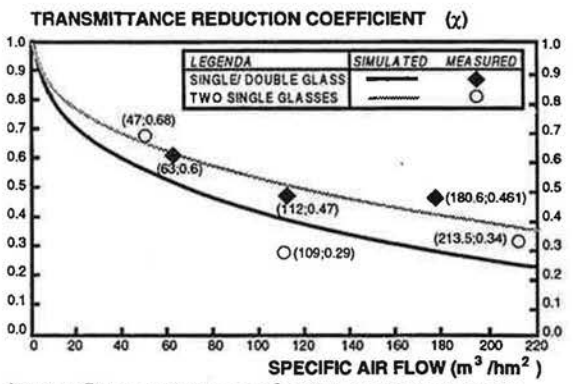

Figure 7Transmittance reduction coefficient versus specific air flow for single / double glass and two single glasses dynamic windows.

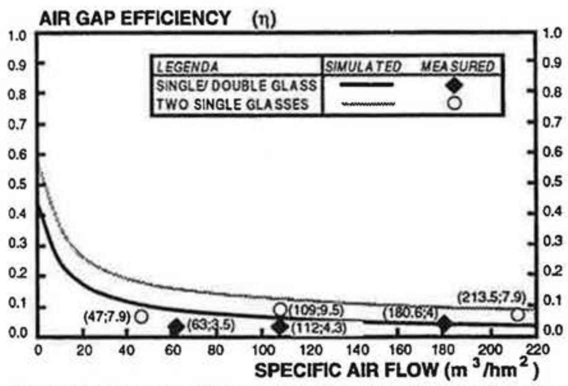

Figure 8 Air gap efficiency versus specific air flow for single / double glass and two single glasses dynamic windows.

The transmittance reduction coefficient (c), after a first drod-down the curve tend to linearize, with increasing air flow rate achieving interesting values at the higher flow rates.

About the air gap" or "equivalent exchanger" efficiency (h) graph, the influence of increasing air flows tends to be cancelled after an air flow rate of 40-50 $m^3/h\ m^2$.

On the other hand we have to consider the relative low cooling in the air gap: just 1°C for single and double glass window and 2°C for two single glasses).

Thus it is possible to use air to air heat recovery plants in series.

New experimental research is aimed to test dynamic insulation windows on external Passys Test Cells at European Joint Research Centre of Ispra introducing solar shading devices with absorbing and reflecting surface, as for winter solar heating and for summer cooling.

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1 The Research group was formed also by G.De Giorgio (Politecnico di Milano, Dipartimento di Energetica) and C.Vancini (CSI).

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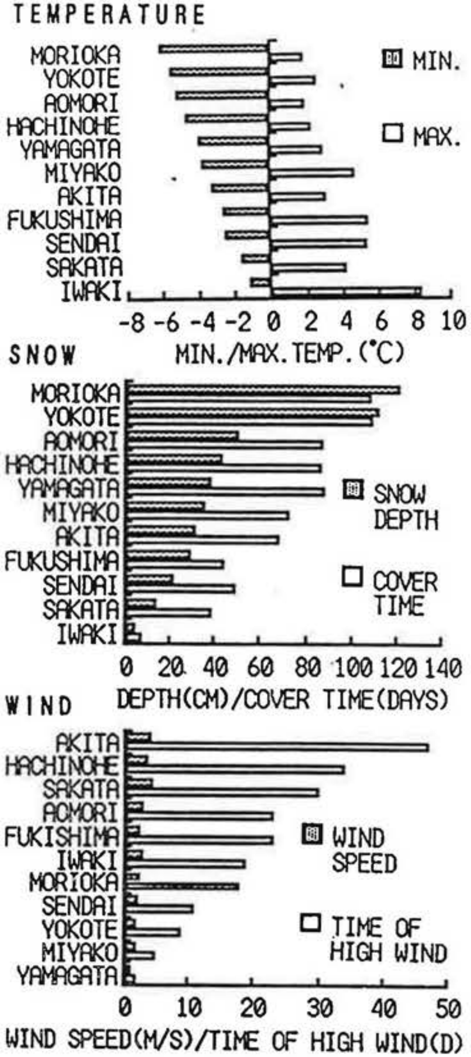
STATISTICAL ANALYSIS OF EXTERNAL COMPONENTS AND MATERIALS FOR RECENT HOUSES IN THE TOHOKU DISTRICT, JAPAN

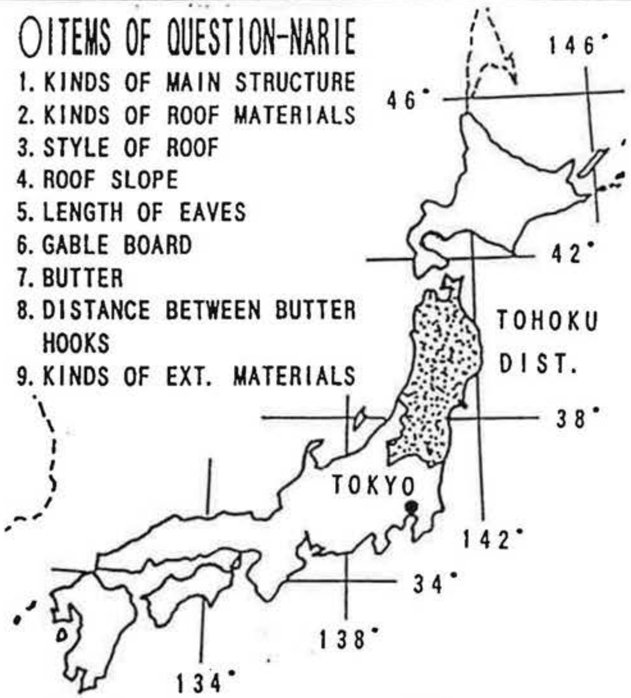
KAZUNOBU HIRAI, TOHOKU UNIVERSITY, JAPAN

○CLIMATE IN WINTER

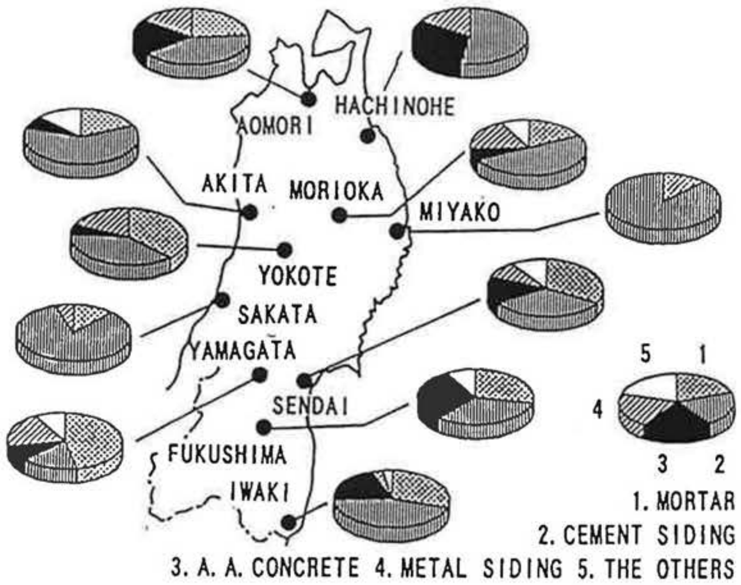


○ITEMS OF QUESTION-NARIE

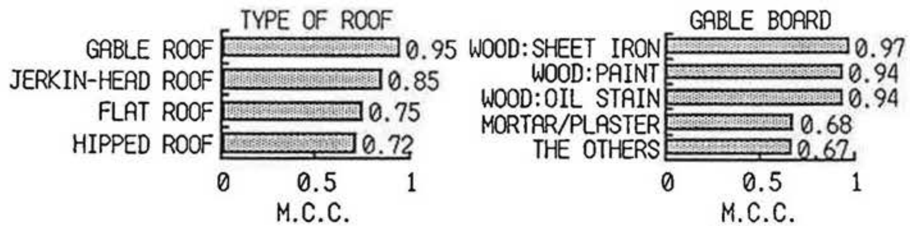
1. KINDS OF MAIN STRUCTURE
2. KINDS OF ROOF MATERIALS
3. STYLE OF ROOF
4. ROOF SLOPE
5. LENGTH OF EAVES
6. GABLE BOARD
7. BUTTER
8. DISTANCE BETWEEN BUTTER HOOKS
9. KINDS OF EXT. MATERIALS

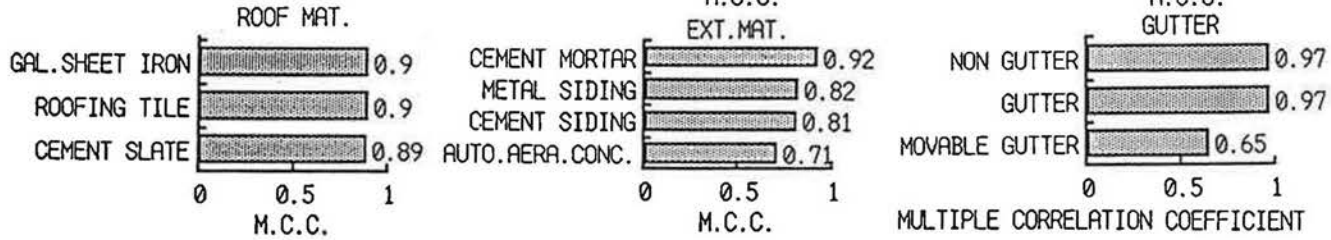


○DISTRIBUTION OF KINDS OF EXT. MATERIALS (AN EXAMPLE)



○MULTIPLE REGRESSION ANALYSIS ON EXTERNAL MATERIALS AND COMPONENTS TO CLIMATIC FACTORS



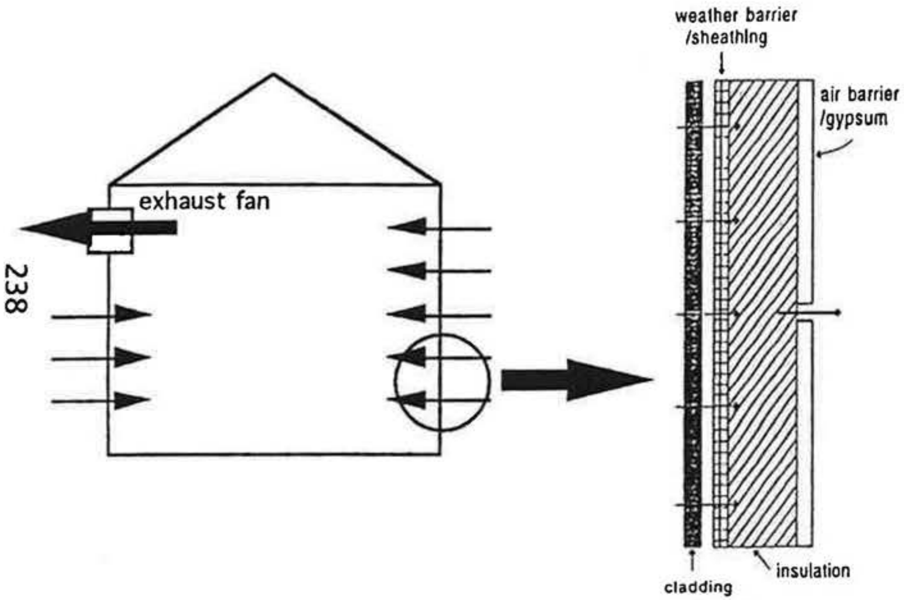


A Monthly-Bin Model for Dynamic-Wall Ventilation

Ian Morrison (Buildings Group, CANMET)

Goal: Incorporate dynamic-wall ventilation into HOT2000(i)

What is a dynamic wall?



It ...

- is a porous insulated wall
- is a supply-air ventilator
- recovers heat from walls
- is a passive solar collector

Predicted energy performance:

- 5% to 12% annual space-heat energy savings relative to a supply-and-exhaust ventilation system which doesn't have heat recovery

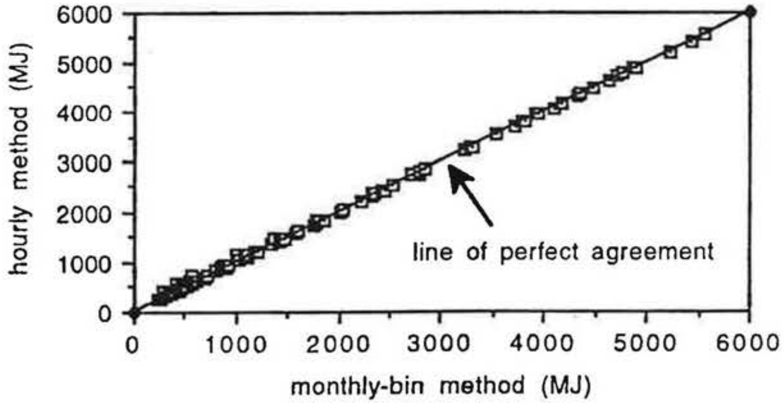
The dynamic wall's performance is affected by:

- the fraction of infiltrating air that flows through the wall's insulation
- the amount of solar energy absorbed on the wall's cladding

The monthly-bin algorithm uses:

- the monthly solar data averaged over eight directions (N, NE, E, SE, S, SW, W, NW)
- the fraction of infiltrating air that flows through the insulation (supplied by the user)

Comparison with an hourly model (infiltration load):



(i) HOT2000 is a monthly-bin simulation program for houses

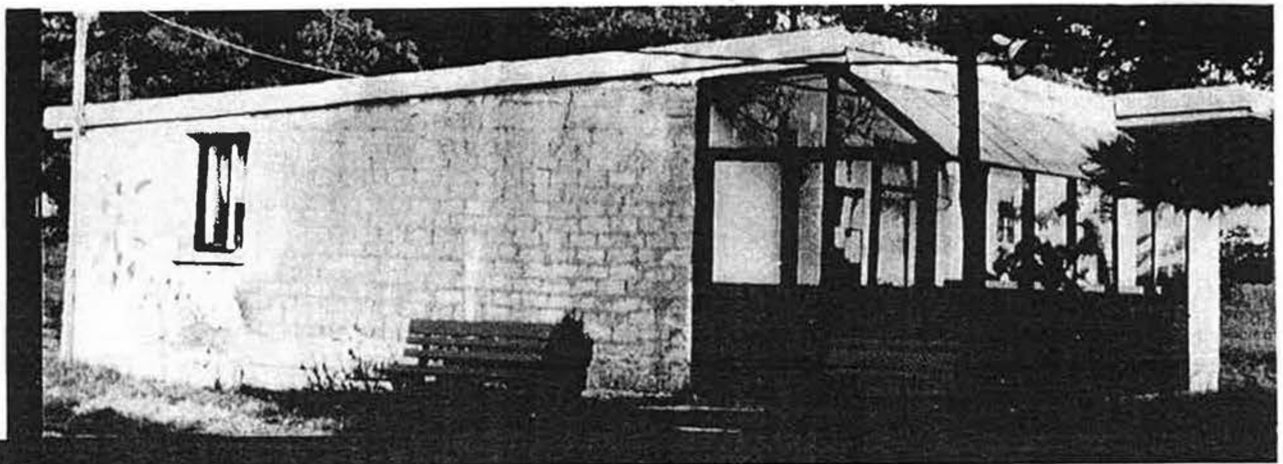
OUTDOOR PLASTER APPLICATIONS ON GYPSUM+ADOBE WALL

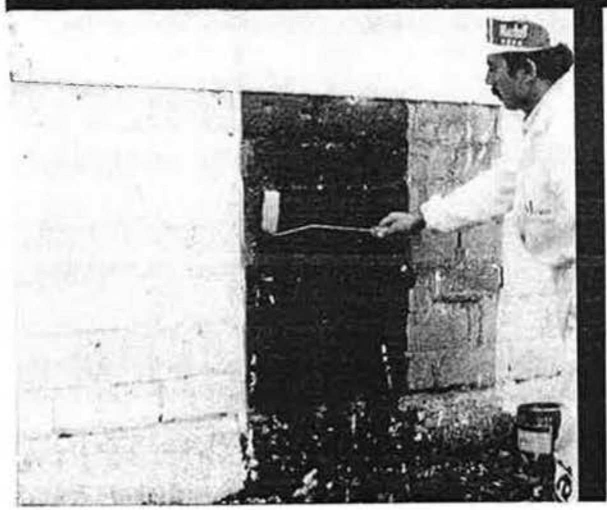
Dr. Bilge Işık (İTÜ İstanbul, TR)

Aim of the project is: to give the modern planners a rivised technologie of adobe
to give the politicians opportunity for rapid settling regarding enegy resourses.

SITUATION

Adobe is vulnerable to moisture. Laboratory research of gypsum-stabilized adobe (1980) ensured the strenght of 30-50 kg/cm². Main advantage of gypsum-adobe is hardening in few minutes, which makes the construction ready for mechanisation. A test-house has been built for case-studies (1983) and since inhabited as Kindergarden of Istanbul Technical University.





RESEARCH

The gypsum adobe building deserved a modern envelop. Ready mixed plaster companies attended the reasearch. They applied 15 different plaster and primers (1991) to the west wall.

OBSERVATİON

The table shows the demage of the plaster in the 1,5 years of five years program (1993).

1.Very little erosion
2.Very little to little
3.Little erosioun
4.Little to moderate

5.Moderate erosion
6.Moderate to serious
7.Serious erosion
8.Very serious

1.	KLT	1,8			9.	MRL	1,8
2.	KLT	2,8			10.	MRL	2,9
3.	KLT	3			11.	SRP	1
4.	KLT	3,4			12.	SRP	2
5.	KNX	1			13.	SRP	3
6.	KNX	2			14.	SRP	4
7.	KNX	3			15.	SRP	5
8.	ABS			Fax 90.1.274 77 21			