EXPERIMENTAL WORK ON A LINKED, DYNAMIC AND VENTILATED, WALL COMPONENT

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ABSTRACT

In conventional construction, the ventilation air enters a building through a combination of 'desired' pathways, via opened apertures, such as a window, vents, and 'undesired' pathways, via cracks such as around external openings, joints between building materials, etc. By contrast, in dynamic insulation construction, the ventilation air is drawn into the building through the insulation material of the wall. Structures with Dynamic Insulation incorporate porous insulating material in the envelope and air is sucked through the porous material across which there is a temperature difference. The aim of this paper is to present the experimental work carried out on a breathing wall component.

A series of tests was carried out at a wall component that is a combination of dynamic insulation panel and a ventilated façade, which was installed at the South façade of a PASSYS Test Cell in the outdoor testing facilities of CRES, Greece. The wall component consisted of two main sub-layers: the Ventilated external envelope and the Dynamic Insulation (DI) sub-layer. The DI component consisted of layers of breathing materials that let the air enter the room at a reasonable pressure difference between the interior and exterior.

This paper describes the experimental work carried out and the results drawn out of the tests performed in the linked wall component with : i) different pressure regimes between the interior and the exterior of the test cell and ii) controlled and floating internal air temperature. In summary, the performance of the component was effective, since conduction losses were decreasing. The construction of such components must be performed with great care (i.e. air leakage control) since it may significantly affect its effectiveness.

1. INTRODUCTION

In conventional construction, the ventilation air enters a building through a combination of 'desired' pathways, via opened apertures, such as a window, vents, and 'undesired' pathways, via cracks such as around external openings, joints between building materials, etc. By contrast, in dynamic insulation construction, the ventilation air is drawn into the building through the insulation material of the wall. Structures with Dynamic Insulation incorporate porous insulating material in the envelope and air is sucked through the porous material across which there is a temperature difference. In Contra-flux Dynamic Insulation the air is being moved through the insulation in the opposite direction of the heat flow. Thus, the ventilation air through the porous material reduces the heat loss by conduction to the exterior of the building envelope. The reduction of the conduction heat losses is also accompanied by pre-heating of the ventilation air before entering the building.

The principle of contra-flux dynamic insulation demands that as much input ventilation as possible enters through porous insulated panels. Thus, the insulation material must permit the passage of air at an appropriate rate. For maximum heat saving effect of the required ventilation air, the amount entering via pathways, but the dynamic insulation, should be minimized. The pressure difference needed to maintain the required flow direction through the insulation material can be eliminated by the uncontrolled infiltration. Thus, uncontrolled ventilation, by doors and windows opening and by infiltration e.g. air passage through gaps between insulation panels or between panels and other building components such as windows and doors, must be minimised in dynamic insulation structures. The dynamic insulation method employs a fan to extract the outgoing air (e.g. from bathrooms and kitchens in a domestic context). This puts the whole building under negative pressure, so that air only passes through the walls in an inward direction (i.e. regardless of wind direction). In principle, the fan is left running permanently throughout the heating season, although its speed can be varied according to wind, temperature and occupancy conditions.

The performance of dynamic insulation was examined with field measurements (Wallenten, P., 1993), hot box testing of breathing materials (Crowther, D., 1994) and experimental tests in a scale model (A. Clare and D. Etheridge, 2001). In the last half century, several buildings applied dynamic insulation on their envelope (Brunsell, J.T. 1995, Lidell, et all, 1996, Cawthorne D., 1997)

2. EXPERIMENTAL SET UP AND MEASUREMENTS PROCEDURE

A series of tests were carried out, under real weather conditions, at the PASSYS Test Cell in the outdoor testing facilities of CRES, Greece, during the winter/spring period on a prototyped ventilated wall component linked to a dynamic insulation panel (Dimoudi et al, 2000). The wall component consisted of two main sub-layers : the Ventilated external envelope sub-layer and the Dynamic Insulation (DI) sub-layer. The DI component consisted of layers of breathing materials that let the air enter the room at a reasonable pressure difference between the interior and exterior. The component was installed at the south side of the test cell, covering its full South wall area and its structural details are shown in figure 1.

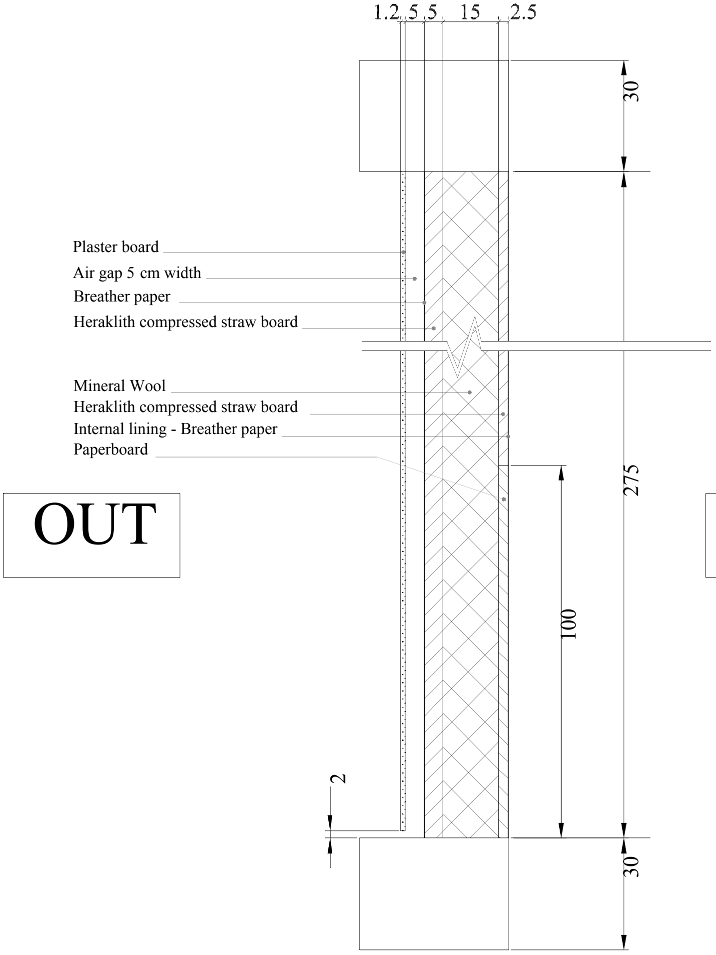


Figure 1. Cross-section of the linked wall component (dimensions in cm).

In order to investigate the performance of the linked wall component, a series of tests was performed with :

- different pressure regimes between the interior and the exterior of the test cell, and
- controlled and floating internal air temperature.

A constant room temperature was applied in the interior of the test cell during the first three test phases, set at 22 °C ± 0.2 °C, while during all the other phases, a free floating temperature regime was utilised. The different Phases during the tests are outlined in Table 1. Each Phase run with a pre-set pressure difference between the interior and the exterior of the test room, aimed to be constant during the whole Phase. In practice, fluctuations were observed during the tests, greatly influenced by the outdoor wind conditions. The standard instrumentation of the Test Cell was used to monitor the performance of the Test Cell. Additional sensors were installed at the different layers of the wall component (Figure 2).

Table 1. Settings applied on the linked wall component tests

Phase Nr.	**Duration**	**Air gap width (cm)**	**Pressure difference (Pa)**	**Room Air Temperature (°C)**	**Comments**
1	9 days	5	-6	22	Heating power applied
2	7 days	5	-10	22	Heating power applied
3	6 days	5	-15	22	Heating power applied
4	11 days	5	-10	Free floating	No heating power regime
5	5 days	5	-5	Free floating	No heating power regime
6	8 days	5	-2	Free floating	No heating power regime

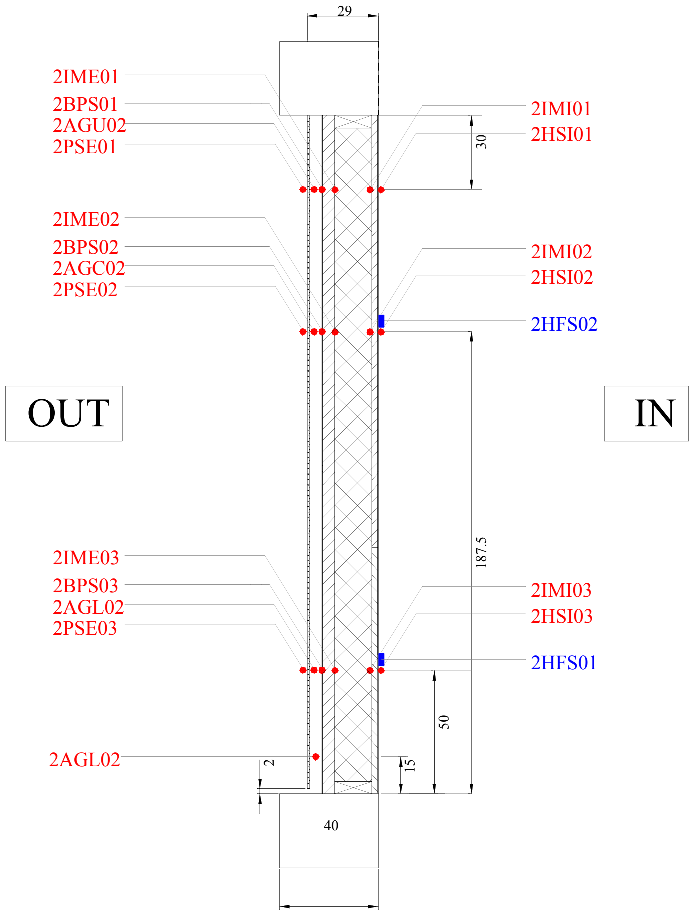


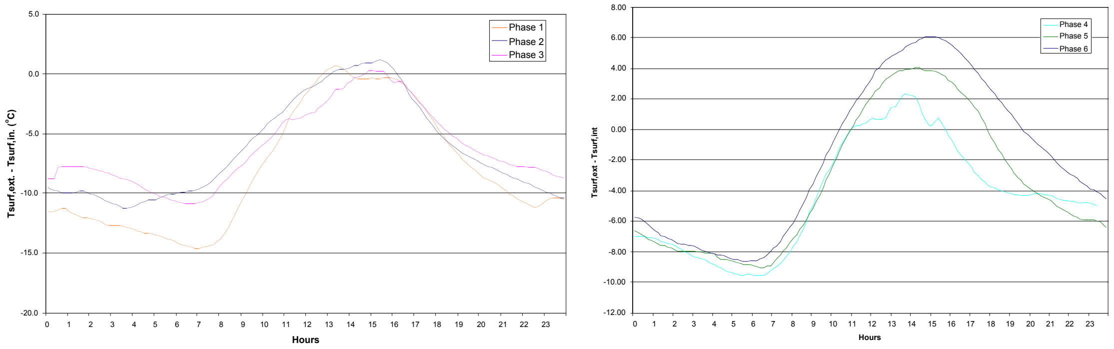
Figure 2. Cross-section of wall component with sensors position and name (dimensions in cm).

3. RESULTS DISCUSSION

Days with similar weather conditions were selected from each Phase in order to assess the relative performance of the linked wall component in terms of different pressure difference regimes between the interior and exterior and indoor temperature control scheme. The Phases were investigated both individually and compared to each other in order to examine the performance of the wall.

Figures 3a and 3b, show the temperature difference between the exterior - the exterior Heraklith strawboard layer that is in contact with the air gap - and the interior surface of the wall for a selected day for each Phase, as this temperature difference is representative of the conductive heat flow through the wall component. It can be observed in figure 3a (Phases 1, 2 and 3) that the smaller temperature fluctuation, representing lower conduction losses, occurred during Phase 3 with the higher pressure differential, while the higher temperature fluctuation occurred during Phase 1. The conduction losses are higher in the night-time than during the day (the effect of solar irradiation is significant).

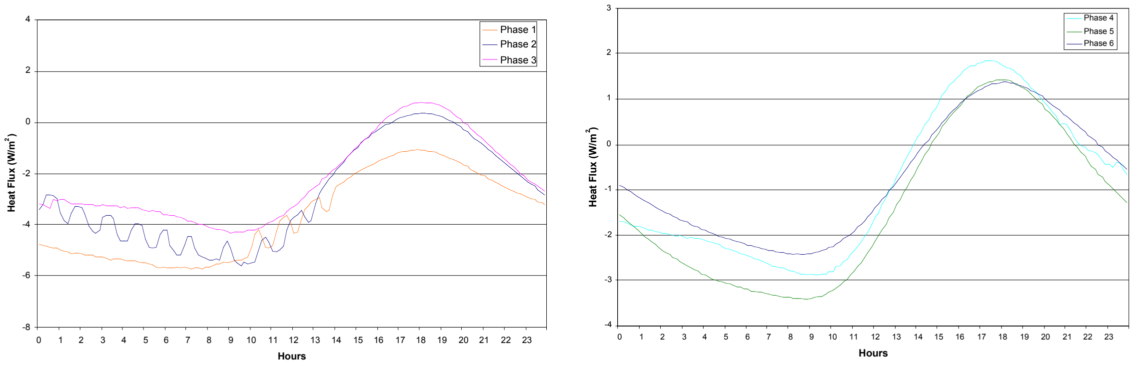
In figure 3b the smaller conductive losses are provided through phase 4 (higher-pressure difference, ΔP= -10 Pa) and progressively as the applied pressure difference decreases, the heat losses through conduction increase.



(a) (b)

Figure 3. Surface temperature difference for : a) Phases 1, 2 and 3, b) Phases 4, 5

Figures 4a to d depict the heat flux (gains or losses) on the wall component for each Phase. It is visible that during the constant room temperature regime (Figure 4a), Phase 3 performs better with lees heat losses during the night and higher heat gains during the day. Under the free floating room temperature regime, Phase 6 has better performance than Phases 4 and 5 (Figure 4b).



(a) (b)

Figure 4. Heat flux through the wall for : a) Phases 1, 2 and 3, b) Phases 4, 5 and 6.

Figure 5 depicts the air flow rate through the wall component against the applied pressure difference. It can be seen that the air flow, as expected, increases with the pressure difference applied between the interior and exterior of the test room.

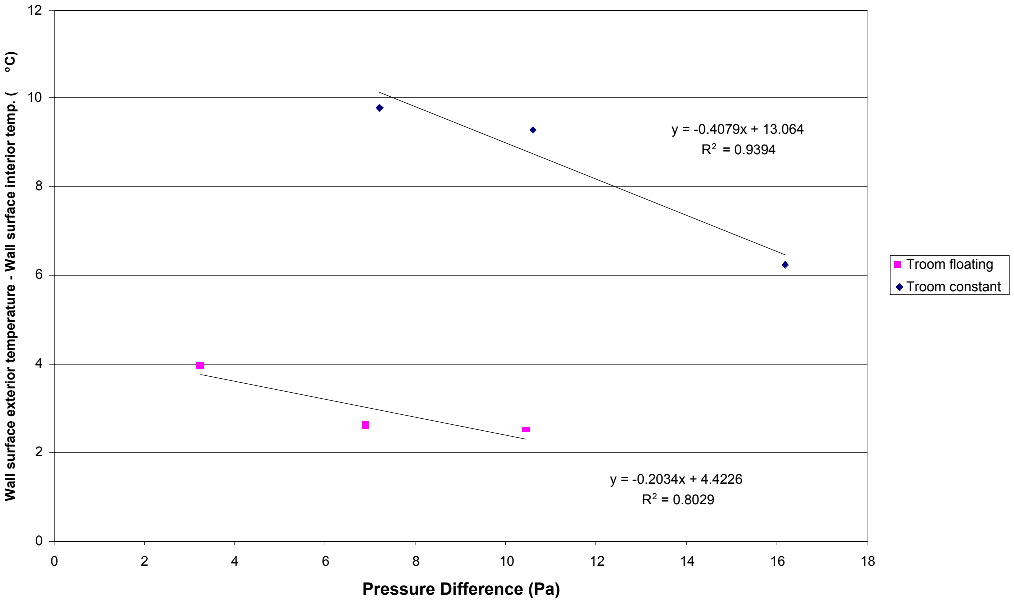


Figure 5. Mean temperature difference, between the exterior and interior wall surfaces of the DI insulation part [BPS_{mean}-HSI_{mean}], (per phase), against the pressure difference.

4. CONCLUSIONS

The results obtained from the comparisons performed lead to the following conclusions :

- under constant room temperature regime, the linked component performs better with higher pressure differences, when operated within a specified range of pressures, i.e. –6 to –20 Pa
- under floating room temperature conditions, again the component performs better under higher pressure differences within the specified range utilised (-2 to –12 Pa)

The wall component seems to perform effectively since the conductive heat losses are decreasing. The air permeability of the intermediate materials must be taken into consideration since it controls the air flow through the component and greatly affects its performance. The construction of such components must be performed with great care (i.e. air leakage control) since it may significantly affect its effectiveness.

Acknowledgments

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