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# Research Report from Norway

## Wind pressure measurements on a rotatable test house


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### Introduction

At The Norwegian Building Research Institute, Division Trondheim, we have been working on a research project involving wind pressure measurements. The main goal of the project is to get more information about the influence of wind pressure on the heat loss from timber frame walls with ventilated airspace between the wind barrier and the cladding. The project is divided into three parts: calculations, hot-box measurements and wind pressure measurements. The project is funded by The Royal Norwegian Council for Scientific and Industrial Research as well as 13 producers of wind barriers or thermal insulation.

### Wind pressure measurements

The wind pressure measurements, which started in November 1985, are necessary to get input values for the calculations and the hot-box measurements. Other goals were to obtain more correct wind pressure coefficients for use in air infiltration models, and to study the possibility of reducing the pressure variations outside the wind barriers by connecting the airspaces behind the claddings and below the roof to a single pressure equalization chamber. This is of interest for the reduction of wind induced infiltration in common constructions, but is also of special importance for developing simple constructions based on the dynamic insulation principle.

A test house has been equipped with instrumentation for wind pressure measurements. By use of an electromotor, the test house can be rotated to any desired position relative to the wind direction. The basic dimensions of the house are: length 9 m, width 5 m, height to the top of the roof 6 m, and roof angle 36°. The location of this house is on an open test area at the top of Tyholt Hill in Trondheim.

By use of 20 pressure transducers (Furness) and a fast data logging system (3530 ORION) the wind pressure at 20 points is recorded simultaneously. By exchanging the plastic tubes connected to the pressure transducers, the wind pressure at 52 different points is measured.

Two groups of pressure points are located on a short wall and four groups on a long wall. The eight pressure points in each group are distributed along a vertical line as shown in

### Inside this issue:

Figure 1 (four on the outside, two in the air space behind the cladding; one on the wall above the cladding and one in the attic 20 mm from the edge). In addition, the indoor pressure and the pressure in the middle of the attic are measured. The static pressure measured 10 m above the ground by a mast on the roof, serves as reference for the pressure transducers. The dynamic pressure measured at the same place is used when calculating wind pressure coefficients.

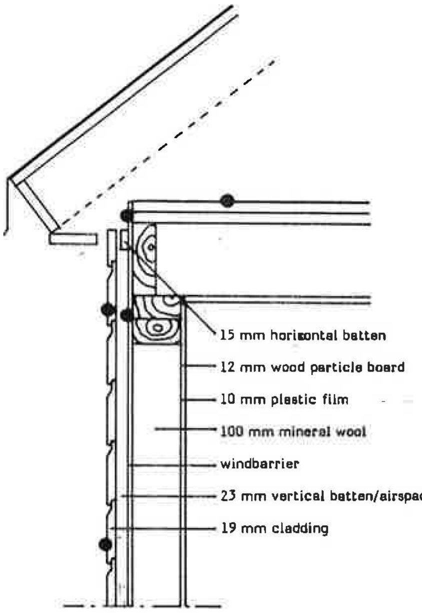


*Figure 1: Example of construction showing the location of measuring points for wind pressure.*

As the wind pressure behind the cladding will be influenced by construction details like the gaps at top and bottom of the airspace behind the cladding, it is necessary to make wind pressure measurements for various construction solutions as well as at various wind approach angles. So far we have investigated three variants. We plan to continue the wind pressure studies on other types of constructions and construction details in 1986. An example of measured pressure distribution at the middle of a long wall is shown in Figure 2.

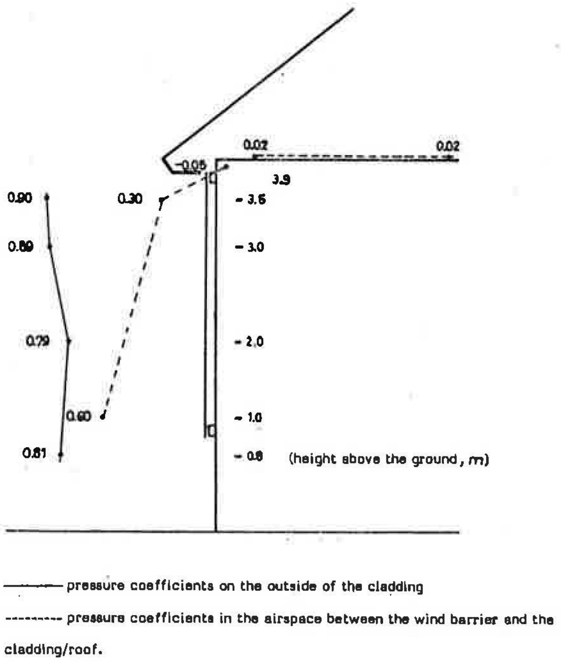


*Figure 2: Example of measured wind pressure distribution at the middle of the long wall. Same construction as in Figure 1. Mean wind speed at 10 m: 15 m/s, approach angle: 0° (normal to the wall).*

## Calculations

The theoretical studies, as well as the experimental investigations in the hot-box, have been restricted to one specific type of forced convection in the thermal insulation, i.e. the interchange of air between the insulation and the airspace between the wind barrier and the outer cladding. This interchange of air is caused by wind induced pressure gradients in the airspace, which normally has small openings at the top and bottom for moisture evacuation. In the mathematical model, based on references 2 and 3, the inside of the wall is assumed to be airtight so that there is no airflow through the structure.

Main parameters affecting this type of heat loss are pressure gradient in the airspace, air permeance of the wind barrier and permeability of the insulation. The computer program is used to estimate the pressure gradient in the airspace, the airflow in the insulation and the resulting heat loss through the wall. The results show the importance of protecting the insulation layer with a wind barrier to achieve full effect of the insulation in wind exposed structures. For wind barriers used in Norway, like asphalt impregnated porous fibreboard, gypsum board and various types of paper, the theoretical model indicates that the increase in heat loss caused by this type of air infiltration is very small.

## Hot-box measurements

To verify the theoretical model for the type of heat loss described previously, several hot-box measurements have been carried out on a timber frame wall of normal size. The guarded hot-box which is used measures 2.45 m x 2.45 m. The test wall was insulated by a 150 mm thick layer of mineral wool and made as airtight as possible on the warm side by use of plastic film and gypsum board. The forced convection was simulated by regulating vertical air flow in the space between the wind barrier and the outer cladding.

The test programme which is almost complete, includes heat loss measurements at various air speeds/pressure gradients without a wind barrier and with nine types of wind barriers. So far the measured increase of heat loss seems to be two to five times higher than calculated. For a wall with a wind barrier and at a pressure gradient of 10 Pa/m in the airspace, the calculated U-value increased from 0.27 W/°C $m^2$ to 0.35 W/°C $m^2$, which is an increase of 30%. The corresponding measured values were 0.28 W/°C $m^2$, 0.52 W/°C $m^2$ and 85% respectively. When the insulation was protected by various wind barriers, the corresponding calculated and measured increase of U-value were in the ranges of 4 – 20% and 7 – 35% respectively. For the construction shown in Figure 1, a pressure gradient of 10 Pa/m behind the cladding corresponds to a wind speed of between 12 m/s and 18 m/s.

A report of the project is planned for the spring of 1986.

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