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AN OUT-SIDE LOOK AT HEAT, AIR AND MOISTURE TRANSPORT IN ENVELOPE PARTS

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1. Introduction

Provoked to present a provocative paper on outside environmental conditions, a short discussion of relevant phenomena is offered. This paper reviews what we need to know about outdoor climate in order to solve HAM-questions. In the Netherlands virtually all current meteorological parameters are measured at 5 stations; rain at 300, temperature and humidity at about 40. What do we want to do with it?

2. Driving rain

2.1. How much rain is deposited on the envelope?

In the UK a driving rain index is developed over the years. A recent summary gives [1]. In the Netherlands a climatology of rain in dependence of wind direction and wind speed is available. This climatology is based on observations with tilted rain gauges [2]. Both studies neglect the influence of the building on the catch. This was subject of some studies, see [3]. Preliminary research indicates that yearly rain in the Netherlands on a southwest facade is about 50% and a northeast facade about 10% of the free field horizontal rainfall in an unsheltered position. In a sheltered position these percentages may be 30% and 2%. Ongoing research based on particle tracking calculations suggests that for the same type of rain and the same orientation of a facade we have at least 50% difference between estimates of driving rain by different authors.

SUGGESTION:
If driving rain is considered of any importance, first define the sensitivity of the HAM problem to driving rain. Define at least how data on rain intensity and rain sum should be combined with wind speed and direction and on which time scale. The required time scale is dependent on processes in the urban atmosphere as well as on the properties of the absorbing material in order to account for the influence of wetness on transport of water within the material.

2.2. Runoff

On impervious material the absorbtion is negligible. The fraction of rain on glass that runs off and the fraction that evaporates at the place it has been caught are not well known. Runoff depends on drop diameter and rain intensity. Apparently runoff is only significant at high rainfall rates. Why there is no shower at the bottom of a completely glazed facade during rain is not yet explained satisfactorily.

Driving rain on impervious materials might not be very interesting for HAM-questions. However, it is relevant to rain penetration. Penetration through joints, cracks etc. depends critically on supply of water through runoff. Also wetting by runoff of absorbent materials placed below an extended glass surface for example should be considered. No quantitative information is available to the author on wetting of porous materials in this way. Detailing of a roof or facade has a significant quantitative effect. However, one can see easily from deterioration patterns on buildings that runoff is not a negligible effect.

SUGGESTION:
If runoff is considered of any importance to HAM questions, a study on the fate of water on the envelope is recommended.

2.3. Rain penetration

Rain penetration is dependent on the supply of water and on pressure differences. Especially with regard to natural ventilation a data base on pressure coefficients is growing, see for example [4, 5, 6]. Pressure coefficients for rural and urban locations differ at least a factor 2.

SUGGESTION:
With regard to water penetration only meteorological wind data can be collected. Some guidance how to correct the wind data and to select pressure coefficients is however necessary. Of course, the meteorological wind data are only relevant if correlated to rain intensity.

3. <u>Evaporation into the atmosphere</u>

The evaporation of non-wet porous materials is mainly determined by the material properties. The evaporation of wet porous materials is strongly dependent on environmental parameters. From measurements of the energy balance of suburban and rural grassland sites as well as on measurements on the energy balance of streets [7], it is clear that the evaporation in the built environment can be 50% less than the rural value. In HAM studies it is necessary to estimate the evaporation from a combined heat and moisture transport study. Such a study includes free field temperature and humidity data, which are generally good enough for urban purposes. However, wind data need attention.
The vapour transfer coefficient is dependent on the speed of the air at a few centimeters from the wall. This speed may be a factor 0.1 to 1.5 or more of the meteorological wind speed. The vapour transfer coefficient changes accordingly. It is possible that this air speed, a few centimeters from the wall, is correlated to Cp. The pressure-coefficient is better known and more easily measured.

SUGGESTION:
If HAM questions are dependent on evaporation into the atmosphere from wet surfaces it might be worthwhile to start a numerical and wind tunnel experiment on the correlation of the pressure coefficient and air speed close to the wall. Collection of climatological data has no practical use in this matter.

4. <u>Heat transfer</u>

Heat transfer between a building and its environment has been subject of much research. Test Reference years have been developed [8-11]. However, there are basic differences between research into the energy requirement of a building and HAM questions. Not the time-scale of the building but that of the envelope is relevant. Solar radiation data are more critical. In building energy studies shading is relevant, in HAM questions also atmospheric turbidity. What has been stated on vapour transfer is also applicable to heat transfer.

SUGGESTION:
It is suggested to make an inventory of the environmental input needed for HAM-calculations and to evaluate this inventory in the light of future developments. On this basis the contents of an environmental data base should be defined.

5. <u>Mass transfer</u>

With regard to outdoor environmental data and mass transfer through the building envelope ongoing research should be mentioned in the UK and the USA on pressure fluctuations at the outside surface [12,13]. Research is needed into the consequences for the pressure difference over the envelope and the mass transfer.

6. <u>Conclusion</u>

1. It might be concluded that task 2 could start with the analysis of processes. The methodology for the collection of data comes in a later stage. Collection of data or of the information on data is out of order at this stage of the project.
2. It seems appropriate to start with a choice of the processes and time-scales which will and will not be included in this study.
3. Critical comments are much welcomed.

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2.3 Task 3: material properties (leading country: Canada)

A round robin on the diffusivity of spruce was initiated by Canada. The paper presented by F. Descamps gives the results obtained in the Lab. of Building Physics. The results of F.I.B, Germany are given in add 3.

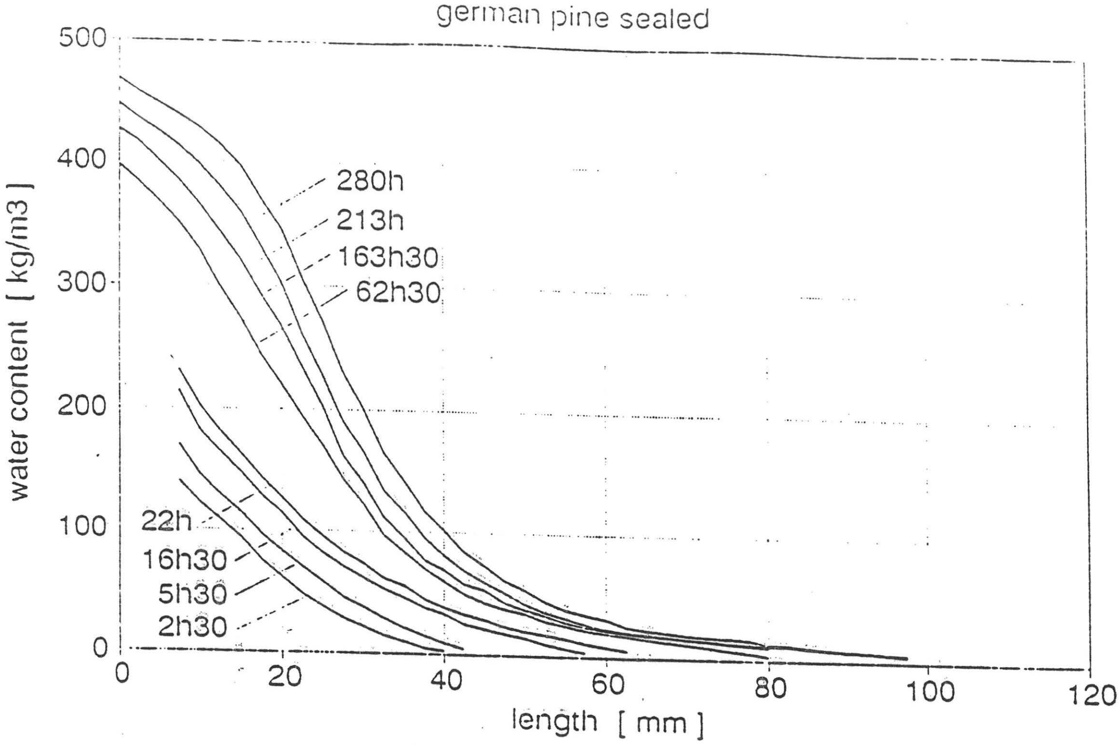

Figure 1: Moisture profiles of sealed german pine at different moments recorded with the aid of the NMR-equipment

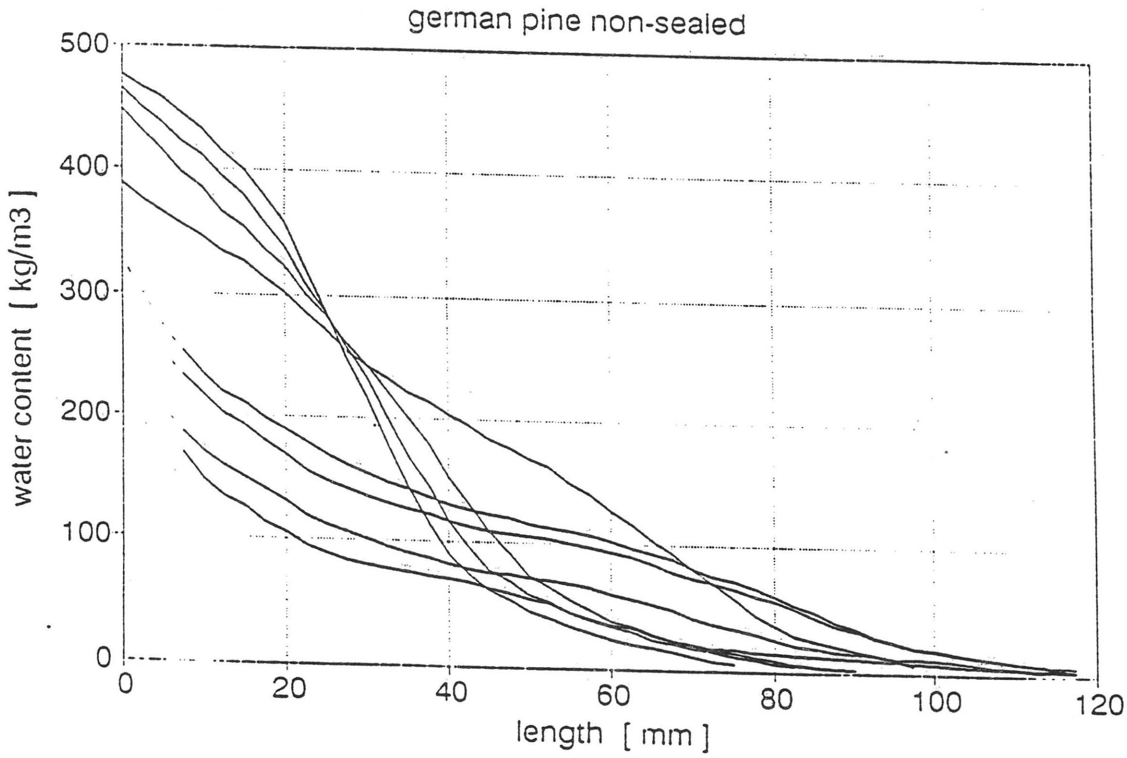

Figure 2: Moisture profiles of non-sealed german pine at different moments recorded with the aid of the NMR-equipment

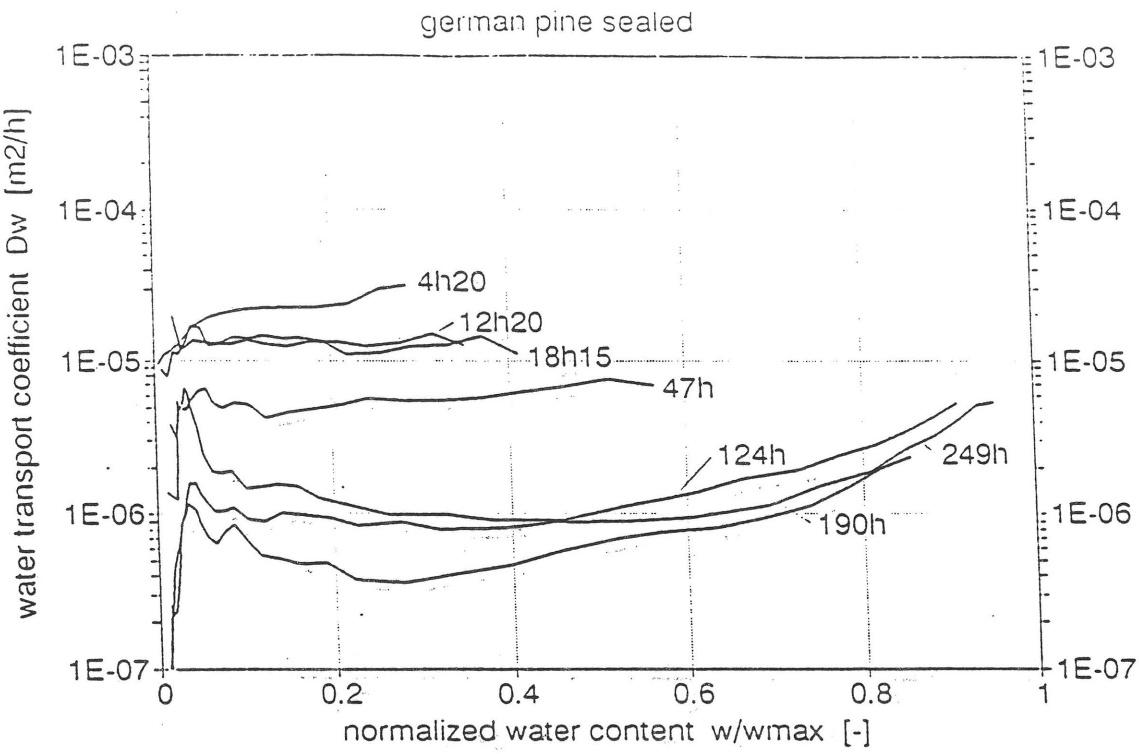

Figure 3: Liquid water diffusivity functions of sealed german pine

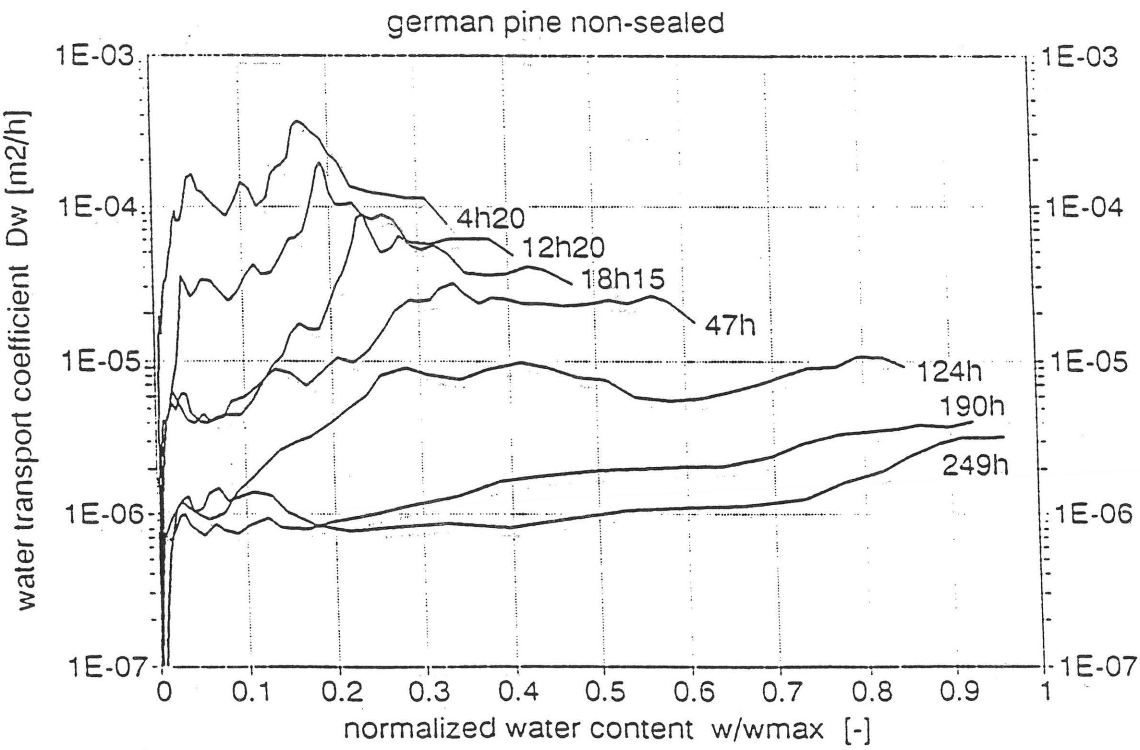

Figure 4: Liquid water diffusivity functions of non-sealed german pine

2.4 Task 4: experimental verification (leading country: Germany)

Here, the work is devided between the different countries:

France : walls with exterior insulation
Germany: walls with exterior, cavity and interior insulation
Canada : timber framed constructions
UK : sloped metallic roofs
Belgium: pitched roofs
Denmark: flat roofs

Germany introduced during the Zürich meeting a very extended set of previous results on different envelope parts, obtained in the 'Aussenstelle Holzkirchen'. Some of their conclusions show the importance of a further exploration of the HAM reality:

- completely filled cavity walls perform better than partly filled walls, a water repellant insulation is not necessary;
- the insulation in a cavity wall is wetter in summer- than in wintertime...;
- roofs with insulated pitches perform better without than with ventilation;

...

Danish results on flat roofs question the demand for a high quality vapour barrier in timber warm roofs. A weaker, but capillar active barrier seems better.
Canadian results stress the importance of air tightness in timber framed constructions.

The paper presented by A. Jansens of the Laboratory of Building Physics on HB-CB tests on pitched roofs is a clear illustration of the kind of work, covered by Task 4.