VENTILATION TECHNOLOGY - RESEARCH AND APPLICATION

8th AIVC Conference, Überlingen, Federal Republic of Germany
21 - 24 September 1987

POSTER P8

CONDENSATION DAMAGE TO TIMBER FRAME HOUSING

DR. S.J-M. DUDEK, MR. G. VALENTINE

Building Science Section
School of Architecture
University of Newcastle upon Tyne
Newcastle upon Tyne
NE1 7RU
United Kingdom

SYNOPSIS

This paper presents and discusses results of moisture transfer into timber frame constructions. The two mechanisms of transfer are diffusion and bulk air movement. Three defects in construction were monitored, punctured vapour barrier, continuous path via an electrical socket and discontinuities at junctions. The study has shown that, under steady-state conditions condensation can take place, while under varing conditions both condensation and evaporation occur. This second case is typical of the building in use, and can prevent high levels of moisture existing in timber components.

INTRODUCTION

The economic climate that has existed in the U.K. in recent times has enabled timber-frame construction to establish a respectable foothold in the U.K. house building market. At the expense of "traditional" construction techniques. Inevitably this has led to criticism of timber frame, some perfectly justified and others less so. The main criticism concerns the likely damage to softwood caused by high moisture content; the source of this moisture being water vapour in the internal air passing into the construction and then condensing somewhere within (Interstitial condensation).

Experimental studies, both at Princes Risborough Laboratory (7) and Newcastle have shown that, under certain environmental and constructional conditions, condensation will occur. However, to infer from this statement that timber frame is at risk from rot is not to fully understand the conditions under which these experiments were performed. For ease of repitition and convenience, steady-state conditions are often applied, either on one or both sides of the construction. Clearly, within the U.K. climate, the external conditions are anything but steady-state and the internal environment also varies with peaks and troughs of moisture production and temperature.

The real situation is complex with periods where condensation can occur followed by periods where evaporation takes place. The net accumulation of moisture is unknown. This article describes a section of work undertaken at Newcastle University Building Science Section. Our primary interest is in the thermal integrity of timber frame and the condensation studies described form only part of a comprehensive study being financed by SERC/University/Darlington Borough Council. What our investigation has shown is that when there is a change of condition across the wall construction which causes condensation to cease, then evaporation takes place and redistribution takes place at a similar rate.

Before these results are presented, a brief description of the mechanisms involved and the experimental set-up will be given.

BACKGROUND

Moisture in the form of vapour can be transported through the fabric of buildings by two mechanisms:

(i) Diffusion
(ii) Bulk air movement (air leakage).

Much attention has been focussed in recent years on the moisture transport problem, especially in buildings with substantial structural timber components. Several studies have addressed the problem rationally (1-7), each in turn contributing to our understanding. However, an absolutely reliable predictive method cannot be deduced because of:

The variation in materials vapour resistance value with temperature and humidity cycles,

The variation of the buildings' internal vapour pressure due to occupant factors,

The variation in standards of construction workmanship,

Uncertainties about the timber moisture content durational threshold for fungal growth.

The theory is as yet unrefined, which necessitates recourse to experimental methods to determine in-service moisture status of the timber components.

TESTING

The present study shows the results of monitoring the moisture content of one full-scale timber-frame wall, Figure 1, under various conditions of vapour barrier workmanship standards and under simplified environmental conditions. The construction was purpose-built full-scale in an environmental test chamber. The wall tested was a typical timber-framed inner leaf with:

1. 12.7mm plasterboard - joints taped and filled,
2. 500 gauge polythene vapour barrier,
3. 97 x 44mm softwood studs with 100mm fibrous insulation,
4. 8mm sheathing plywood (3 ply),
5. breather membrane.

Three typical vapour barrier defects were installed in a test wall:

punctured vapour barrier material ,

local destruction of the vapour barrier due to fitting a socket outlet,

discontinuities at junctions.

The environmental conditions were varied very simply in step fashion, as shown in Figure 2, over the test period of 20 days. In essence both the air pressure and vapour pressure differential were reduced independently, to investigate both the diffusion and air leakage processes.

The internal temperature was 21 °C and the external temperature 2 °C and this differential was held constant. Step changes in humidity were used to produce changes in vapour pressure differences and mechanical fan extraction used to create air pressure differences.

DEFECTS

Vapour Barrier Holes

Holes in the polythene vapour barrier 250mm and 500mm square were made at a height of 0.5m above ground floor skirting level, to represent possible workmanship errors.

These defects were vapour barrier discontinuities only with intact plasterboard and were subject to diffusion transfer.

Electrical Socket

An electrical socket was installed in the wall. The vapour barrier was cut neatly around the socket box, but not sealed to the electric cable. This afforded an air leakage path via the cable to the first floor joist space.

This defect involved both plasterboard and vapour barrier discontinuities and was subject to air leakage transfer and diffusion.

Junctions

A solid ground floor/wall junction and a timber first floor/wall junction were also studied. At the ground floor/wall junction there was a discontinuity between the polythene damp proof membrane and the polythene vapour barrier and a void in the mortar bed. The first floor/wall junction had the typical U.K. practice of discontinuity in the insulation and vapour barrier at the junction. The leakage rates for these two floor junctions were 1.50 and 0.05 m3/hour at 7 Pascals respectively.

This defect involved both plasterboard and vapour barrier discontinuities and was subject to air leakage transfer.

RESULTS

The results of the experiment are presented in Figure 2. and show the variation in moisture content monitored on the inside surface of the plywood sheathing. No moisture content increase was recorded on the outside face of the plywood sheathing.

Vapour Barrier Holes

During constant vapour and air pressure differentials, the rate of increase in moisture content of the sheathing was 1.0% and 0.2% per day for the 500mm and 250mm holes respectively. A step change in air pressure caused no discernible change in the rates of increase. However, when the vapour pressure was step changed, a rapid decrease in moisture content took place.

Electrical Socket

The moisture content of the sheathing opposite the electric socket increased with time under both vapour and air pressure differences. A reduction in either pressure condition was accompanied by decreases in moisture content.

Junctions

The moisture content of the intermediate floor header joist never rose above 15% but the sole plate rose to 17%, the latter moisture contents reduced rapidly with zero air pressure differences.

CONCLUSIONS

The following conclusions can be drawn:

Interstitial condensation occurs on the plywood sheathing adjacent to vapour barrier holes. On removing the principal driving force, vapour pressure difference, evaporation and redistribution takes place.

Bulk air movement into the structure causes condensation to take place on the plywood adjacent to the air leakage path. Resulting in an increase in moisture content of the sheathing. When either vapour or air pressure differentials are reduced, then a decrease in moisture content takes place.

Bulk air movement through the construction causes local increases in moisture content of plywood, but acts to increase evaporation when humidity levels of the moving air are low.

This study has shown that, under steady-state conditions, condensation can take place within timber frame constructions. However, when varying conditions apply, both condensation and then evaporation can take place. Under real conditions, both internal and external conditions vary independently, providing periods of condensation and then evaporation which do not significantly alter the moisture content of the timber components.

REFERENCES:

1. CLOUGH R.

When the risk appears

Building 1983 Dec. 2nd p. 47

2. COVINGTON & McINTYRE

Timber-frame wall material

Building Research & Practice 1985 p. 207-210

3. SHERWOOD

Condensation potential in high thermal performance walls - cold winter climate.

U.S.A. Forest Products Laboratory Report 433 1983

4. WANG

Comparative studies of vapour condensation potentials in wood-frame walls.

ASHRAE/DOE Conference 1979

5. RODWELL

Water vapour diffusion through plasterboard wall linings and damaged vapour barriers.

Building Services Engineeer 1977

6. JOHNSON K.A.

Interstitial condensation

Building Technical File 1985 Jan. No.8 p.73-79

7. COVINGTON & McINTYRE

Moisture conditions in the walls of timber frame houses- the effects of holes in vapour barriers.

B.R.E. Report 1986

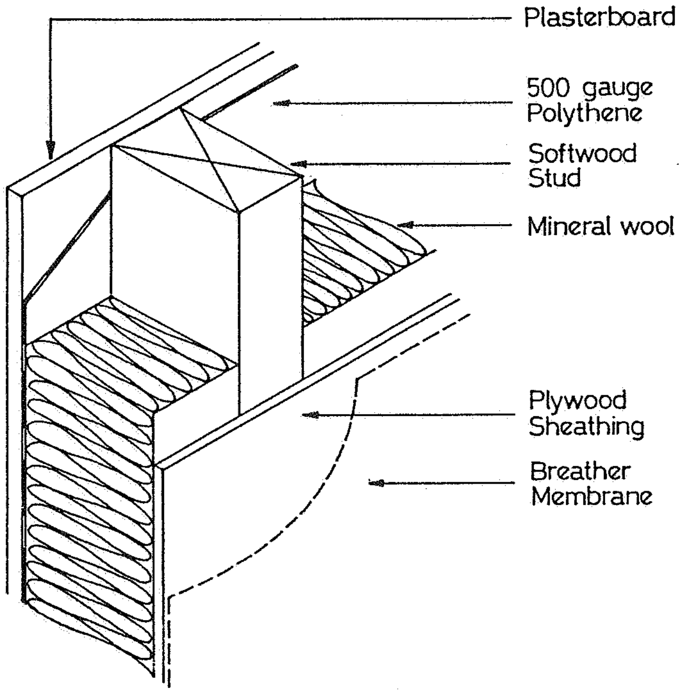

Figure 1 - The wall details.

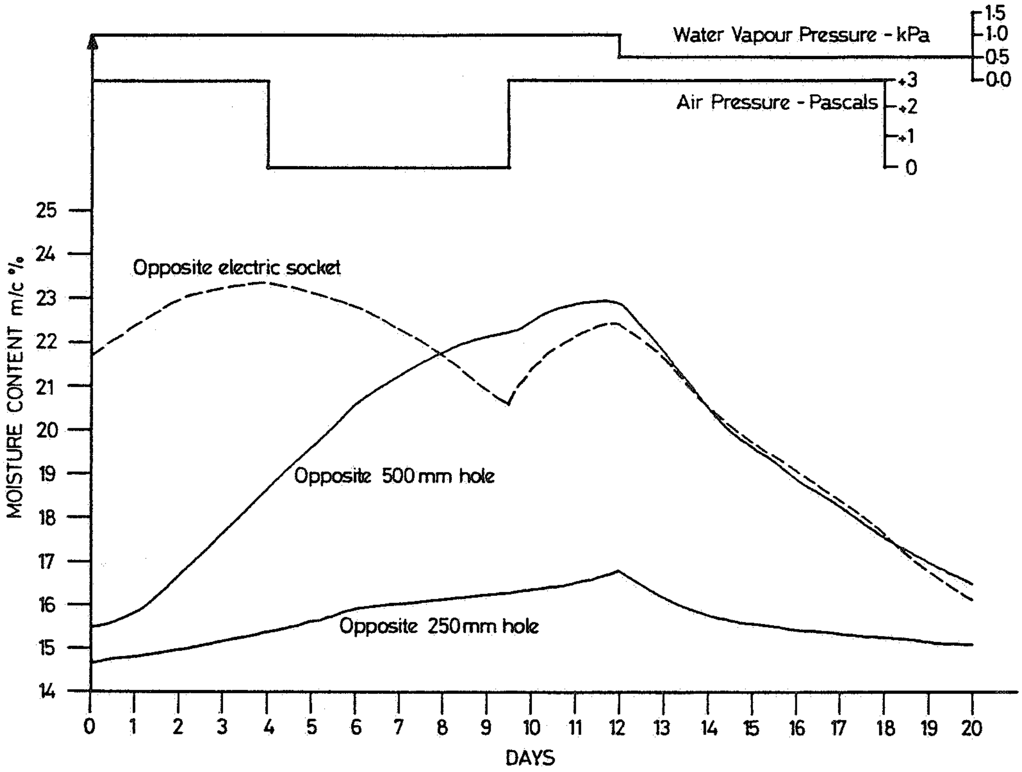

Figure 2 - Moisture content of plywood sheathing.