RESEARCH HIGHLIGHT

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Evaluation of Vapour Diffusion Ports on Drying of Wood-Frame Walls Under Controlled Conditions

INTRODUCTION

As part of the effort to address the leaky condominium problem in British Columbia, it is necessary to understand how walls manage moisture. A 1998 best practice guide indicates that walls require four features for effective moisture management: deflection, drainage, drying and durability. Of the four, drying has received little attention. For this reason, the Building Envelope Research Consortium (BERC), an industry and government group formed by Canada Mortgage and Housing Corporation (CMHC) to address the condominium problem, undertook an Envelope Drying Rate Analysis (EDRA) experiment as part of its program.

Typically, permeance is used to calculate drying rates. However, the effective permeance of a wall may be several times greater than the calculated permeance. Efforts have been made to improve the effective permeance of walls. One approach involves creating one or two holes 75 mm in diameter in the sheathing at the top and bottom of stud spaces; a concept initiated in the B.C. lower mainland by Vancouver architect Brian Palmquist, of ProPacific Architecture Ltd. These holes, known as vapour diffusion ports (VDPs), allow vapour in the stud space to contact the sheathing protection membrane directly.

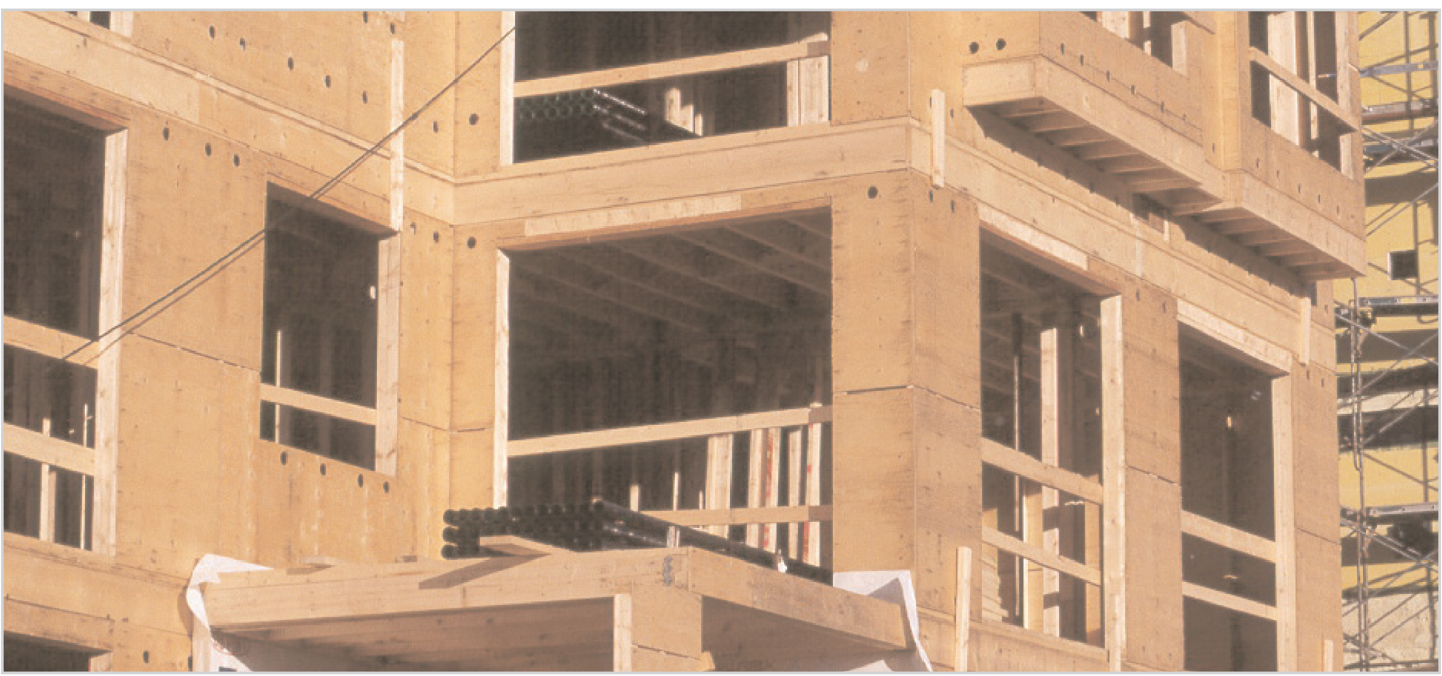

Figure 1 Vapour diffusion ports in field application

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On completion of the EDRA study, Forintek Canada Corporation used the same panels to evaluate the effect of vapour diffusion ports on the drying capability of wood frame test wall panels. These panels were tested in a controlled laboratory environment simulating the winter climate of Vancouver.

More specifically, the test aimed to address the following objectives:

1. To determine how long specimen wall panels take to dry with and without VDPs when wetted to more than 25 per cent moisture content (MC).
2. To determine and compare the drying rates for different types of wall panels (oriented strand board and plywood) with and without VDPs.
3. To determine if there is a substantial change in effective permeance with VDPs.

METHODOLOGY

Limited variables

Given scope and cost considerations, the test limited the number of variables between the test panels and test conditions. Forintek accomplished this, in part, by subjecting all wall panels to the same drying forces. This allowed them to quantify the differences in the drying rates between the panels based on their design, without having to factor out differing drying conditions, seasonal variations, solar orientations, wind effects and so forth. The test sought to handicap the panels equally so that the differences in drying rates could be attributed only to their designs.

Testing conditions

The testing chamber was conditioned to 5°C (41°F) and 70 per cent relative humidity (RH), with a temperature variance of not more than ±1. 5°C (2.7°F) and an RH variance of not more than ±5 per cent. Light sources subjected all panels to an 8-hour solar cycle. The goal was to achieve a combined ambient and solar temperature of up to 15°C (59°F) at the surface of the panels.

The panels were placed in an indoor test chamber for up to three months to measure their drying.

Test panels

The 6 test panels had been constructed and exposed to two cycles of wetting and drying as part of the original EDRA study. Each test wall panel was 1200 mm x 2400 mm (4 ft x 8 ft) in size. The material for the base panel frame was nominal 38 mm x 89 mm (2 x 4 in) J-grade lodgepole pine, with either 11.5 mm (15/32 in) oriented strand board (OSB) sheathing or 12.5 mm (1/2 in) Canadian softwood plywood (CSP) sheathing. For the purpose of this study, twelve 75 mm VDPs were carefully cut in each of five panels; two at the top and the two at the bottom of each stud space. A sixth panel was tested without VDPs.

As lumber variability has been a problem in other experiments, J-grade was chosen because it has the narrowest range of wood variability. A sorting process resulted in the lumber being separated into four groups according to the average weight gain of each piece in wetting and its average weight loss in drying, with standard deviations noted (s.d.):

- Group A: maximum wetting 63 per cent s.d. 5; maximum drying 30 per cent s.d. 4
- Group B: maximum wetting 59 per cent s.d. 7; maximum drying 19 per cent s.d. 5
- Group C: maximum wetting 49 per cent s.d. 5; maximum drying 20 per cent s.d. 2
- Group D: maximum wetting 40 per cent s.d. 5; maximum drying 12 per cent s.d. 3

Panels were constructed using a piece from each group for the four studs and plates.

Five panels had 19 mm cavities, and one had a 10 mm cavity. Three had cavity venting at the bottom only, and three had venting at the top and the bottom.

Prior to wetting, the panels were fully clad (stucco) and instrumented, but left uninsulated and with no interior finish. This allowed the panels to be placed studs (inside face) down in shallow tanks of water to evenly wet the lumber. All panels were subsequently insulated in the stud space (R14) and edge sealed with vapour impermeable roofing membrane.

Difference between test and field conditions

The study was not intended to replicate how walls will perform in the field. The results, therefore, cannot be used to determine whether walls built to code from 1985 to 1998 were inadequate in their drying capabilities. Some of the variations from field conditions were as follows:

- The test panels were not wetted to simulate wetting in the field, but to distribute the moisture in a controlled manner and apply the same moisture load to all of the panels.
- All wall panels were exposed to the same environmental conditions and at a steady state, rather than simulating real weather conditions. For example, the test panels were not subjected to random wind and air movement, and the solar cycle was consistent for all panels.
- The test panels did not include any envelope penetrations, such as windows and vents.

- The panels were not built with the same kind of airtightness as in the field, nor were they subjected to pressure differentials similar to those in the field.
- The drying regime included steady state temperature and relative humidity conditions only for wintertime in Vancouver.
- Estimates of moisture content in the framing were corrected for species and temperature, and are quite accurate for readings in the 15 to 25 per cent range. Above 25 per cent MC, the readings become less accurate. Estimates of moisture content in OSB and plywood sheathing are an indication only.

FINDINGS

Panels with VDPs dried faster than those without. Those without did not enter into the final drying stage until after 800 hours, whereas panels with VDPs began the final drying stage as early as 600 hours into the test.

Panels with OSB sheathing had substantial increases in their performance with the addition of VDPs. In contrast, there was no substantial increase in the drying rate of the plywood panel with VDPs. Panels with top and bottom vented cavities dried faster than comparable panels vented only at the bottom.

The overall drying rates of panels can be quantified by looking at their effective permeance. Calculations were based on total moisture loss over the test period. The panel with a 19 mm cavity, bottom vent, building paper, plywood sheathing and VDPs had the highest total effective permeance. Its results were substantially the same as when it had no VDPs, indicating that these ports likely have no significant effect on the drying performance of plywood sheathed panels. The OSB panels, however, showed a substantial change in their permeance levels, demonstrating a significant improvement with VDPs.

The moisture content in the studs at the time of installation measured 34 per cent and at the time of removal averaged 12 per cent. There were no test panels in which all locations in all components dried to below 19 per cent MC by the end of the test.

The framing dried on average below 19 per cent MC in less than 650 hours. The OSB and plywood sheathing generally stayed about 19 per cent MC to beyond the end of the test.

OSB sheathing without VDPs finished with an average moisture content in the range of 35 to 36 per cent. The same panels with VDPs finished with an average moisture content in the range of 22 to 25 per cent. This substantial improvement in the drying of OSB panels was achieved with a 10 per cent shorter drying time.

Examination of moisture sensor data indicates redistribution of moisture from the framing to the sheathing over the first 500 hours. Once the redistribution is complete, there follows 1,000 hours of very slow drying in the panel overall.

Panels with OSB sheathing and VDPs had a rise in average sheathing moisture content of 2 per cent over the test. The same panels without VDPs had a much higher rise of 12 per cent, due to transfer of moisture out of the studs into the sheathing.

CONCLUSION

Vapour diffusion ports can make a substantial difference in OSB-sheathed panels, but are likely to make no substantial difference in plywood sheathed panels. The OSB-sheathed panels in the test had substantially higher per cent moisture loss, higher effective permeance and a lower per cent moisture content in the sheathing and framing with VDPs than in the same panels without VDPs. In the plywood sheathed test panel, VDPs had no substantial impact on the drying rate.

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Further testing should be conducted on wall areas that have large concentrations of lumber, such as window headers and rim joists, to determine if VDPs can enhance drying in these areas.

Assemblies using VDPs should be tested to determine if they have any negative effects on deflection and drainage. The effect of vapour diffusion ports on the structural properties of walls should be tested and any revisions to design loads evaluated for overall performance of the structural aspects of the wall system. The field effectiveness of vapour diffusion ports should be evaluated in outdoor test huts and through monitoring of buildings where they are currently being used.

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Housing Research at CMHC

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