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Publisher's version / Version de l'éditeur:

Research in building physics: proceedings of the 2nd International Conference on Building Physics, 14 - 18 September 2003, Antwerpen [i.e. Leuven], Belgium, 2003-09-01

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NRCC-46103

**A version of this document is published in / Une version de ce document se trouve dans:
2nd International Building Physics Conference, Leuven, Belgium, Sept. 14-18, 2003, pp. 1-10**

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Assessing the hygrothermal response of wood sheathing and combined membrane-sheathing assemblies to steady-state environmental conditions

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ABSTRACT: The hygrothermal performance of building envelope system is dictated by the response of the system to combined heat, air and moisture fluctuations produced by exterior and interior conditions that exist on either side of the envelope. This study was undertaken to generate information that would assist the benchmarking hygIRC model and related methods to assess hygrothermal performance of wall assemblies. This paper reports on experimental results to assess the drying rate of various combinations of sheathing membrane in close contact with wood-based sheathing. A weighing system was devised to conduct drying experiments on wood based products that would retrieve data on the change in weight of specimens continuously over time from which the hygrothermal response of the specimens could then be determined. Specimens consisting of saturated wood sheathing board products of approximately 0.8-m by 1-m size and weighing 5-kg, were either wrapped in different types of sheathing membrane or directly exposed to uniform environmental conditions in a climate chamber. Results provide a measure of the hygrothermal response of the different combinations of sheathing and sheathing membrane and establish rates at which drying occurs in these products. The results are useful in helping benchmark mathematical hygrothermal simulation model hygIRC.

1 INTRODUCTION

Assessing the performance of new building materials, components or systems typically requires extensive laboratory testing or, in some instances, elaborate and time-consuming field trials. Thorough analyses of the hygrothermal behaviour of, for example, wall systems in response to different climatic loads are not usually part of the assessment process. Whereas laboratory and field experiments are often too selective and time consuming, a practical means of assessing the response of wall systems to changing environmental loads is accessible through the use of hygrothermal simulation models. Simulation models can accommodate a variety of changing boundary conditions and as well, result in much faster analysis, given the recent advances in computer technology that have permitted ready access to enhanced computing performance. This in turn has brought about an increased emphasis on the use of numerical methods to solve the fundamental hygrothermal equations that form the basis for many of the mathematical models developed over the past decade. Depending upon the complexity of the problem under consideration, such models can be

based on very simple, one-dimensional, steady state methods or on more complex, two and three-dimensional, transient methods. However, acceptance of results derived from simulation models is contingent upon acquiring evidence of a response comparable to that obtained from experimental work when the simulation is carried out under the same nominal environmental loads. Studies that incorporate both laboratory experimentation and simulation thus offer possibilities to compare results and hence 'benchmark' the response of the model to known conditions such as hygIRC (Maref et al. 2002 (a) and (b)).

2 EXPERIMENTAL APPROACH

2.1 Objectives

A series of experiments have been conducted to gather data on the drying rate of wood-frame wall assemblies as well as wall components subjected to controlled steady and transient state conditions. The experimental work was designed to achieve two main objectives:

- Measure the overall hygrothermal behavior of wood-based components in wood-frame construction when subjected to steady state and transient state hygrothermal conditions in a controlled laboratory environment; and
- Validate the prediction of the drying rate of wood-based components from results using the model 'hygIRC' through comparison to those of the laboratory experiment [Maref & al., 2002a and 2002b].

2.2 Method

To achieve the above objectives, two series of drying experiments (Sets I and II) were carried out in controlled laboratory conditions on sheathing boards having nominal dimensions of 0.8-m x 1.0-m (referred to as 'mid-scale' series). This size had been deemed a reasonable compromise between small and full-scale experiments. This series of tests were conducted such that technical advantages gained from completing this series could subsequently be applied to full-scale experiments that were conducted as part of broader and more comprehensive benchmarking exercise. The mid-scale series included not only OSB (Oriented Strand Board) sheathing but also combinations of OSB in contact with different water resistive barrier materials or other materials.

2.3 Equipment, materials and procedures

A brief description of the test equipment used in these tests follows. Essentially it consisted of a set of three (3) weighing systems housed within an environmental chamber.

2.3.1 Weighing System

Three weighing systems were fabricated, each one capable of accommodating three specimens as shown in Figure 1. Specimens were attached to individual load cells (nominal capacity of 50 ± 0.02 kg) such that weight changes could be monitored over the course of the experiment [Maref et al. 2002c]. Weight changes of a total of nine different specimens could simultaneously be monitored from load cell measurements recorded on a data acquisition system. These weighing systems were placed in a climatic chamber (referred to as the Envelope Environmental Exposure Facility (EEEF)) and the specimens attached to them were thus subjected to climatic regime to which the chamber was regulated.

2.3.2 Climatic Chamber

The EEEF was used to subject the specimens to simulated climatic conditions over extended periods of time. The climatic conditions within the chamber can be varied over a range of -47 to $+48 \pm 0.5^\circ\text{C}$ with the capability of either, maintaining a steady state set point, or executing a temperature ramping regime. Humidity control is achieved through a pneumatically actuated fogger coupled to a set point controller and can maintain humidities ranging from 10 to 100 % RH within 3 % RH in steady state conditions.

2.3.3 Materials

Relevant physical properties of the materials used in the experimental sets are provided in Table 1, and Figures 2 to 5. Values for the absorption isotherm for OSB board are given in Figure 2, whereas in Figures 3 and 4 are the absorption isotherm for sheathing membranes II, III et V and VII and X respectively. Values of vapour permeability in the x-direction are given in Figure 5 for OSB, and membranes II, III and V; the corresponding values for membranes VII and X remain constant and are equal respectively to 6.08×10^{-13} kg/m $\cdot$ Pa $\cdot$ s and 3.76×10^{-13} kg/m $\cdot$ Pa $\cdot$ s.

2.3.4 Data Acquisition

The data acquisition (D/A) and control system (Figure 6) consists of three basic hardware modules. A command module, a data multiplexer and a digital multimeter. The command module is housed within a modular power supply unit. The command module transfers software instructions from a local computer (central processing unit - CPU) to the automated data logging multiplexer to collect and measure data on the digital multimeter. Readings were taken every 10 seconds and directly downloaded to the hard drive where access to the data could be made on a continual basis.

Outputs from each of the load-cells (Figure 6), affixed to the central beam, are connected to a multiplexer unit (HP-E1476A) that is linked to a timer relay; this relay activates the upward and downward motion of the pneumatically driven central beam. The relay signal is connected to the D/A system such that the readings are only taken when the timer relay is activated and the load-cells are under tension. The relay timer was set such that the load cells are operative for 20 minutes of every forty minutes and when operative, the load cell outputs are scanned and recorded by the D/A every two minutes.

The software program is used to collect data from both the moisture pins and load-cells. It also per-

mits the configuration of operation parameters such as the frequency of acquisition cycles, the duration of the test, file name were the data is recorded.

Data loggers were used to acquire the temperature and relative humidity profile of the chamber. The data was reconciled with the gravimetric and other sensor data following the completion of an experiment. The data was acquired every 10 minutes and held in the local memory until retrieved by downloading to another computer.

2.3.5 Moisture Sensors

Moisture pin pairs (DELMHORST type) were used to assess the bulk moisture content of wood-based materials (Figure 7). Calibration techniques used to determine the moisture content as a function of material resistance are described below.

2.3.6 Calibration-Test procedure

The procedure for determining the moisture content in OSB specimens calibrated to readings taken from electrical resistance measurements using moisture content gauges essentially consists of saturating a series of specimens of known size and weight and thereafter slowly drying these such that moisture contents based on weight changes can readily be correlated to corresponding measurements using moisture content (resistance) gauges.

2.3.6.1 Specimen Preparation

A series of 15 specimens of nominal size 11.5 x 150 x 150-mm were cut from a standard sheet of 1220 x 2440-mm OSB. Note was taken of the orientation of strands on the surfaces of the specimens such that moisture pins could subsequently be oriented in the direction of the strands, as required for the test procedure. The initial thickness of each specimen was then measured at its four extremities, 12-mm from the outside edges, to the nearest 0.001-mm using precision calipers. Pairs of insulated moisture pins of 28-mm length were then inserted into pre-drilled holes spaced ca. 25-mm apart (Figure 7). The holes were bored to varying depths. One specimen was instrumented with moisture pins inserted to $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ specimen depth and the remaining 15 specimens instrumented with moisture pins inserted to $\frac{1}{2}$, and $\frac{3}{4}$ specimen depth. Each pair of pins was located on the specimen such that the line between pin pairs was parallel to the principal strand (wafers) orientation in the layer to which they were subsequently inserted.

2.3.6.2 Calibration procedure

The specimens were weighed and the laboratory conditions recorded (i.e. temperature and relative

humidity) such that the moisture content could subsequently be determined. (Note that this weight is not necessarily the equilibrium MC of the material at these conditions). The specimens were then immersed in water to achieve saturation insuring that all free surfaces were completely immersed (Figure 8). An initial three-day immersion period was used following which confirmation that saturation has been attained was determined by monitoring the weight change of several specimens at 4-hour intervals over the fourth day.

Moisture measurements were taken on all specimens (Figure 9) and the differences between the $\frac{1}{4}$ depth readings and the core moisture readings examined to determine evidence of any significant moisture gradient and hence to verify if the specimens have achieved a uniform moisture contents. If a gradient was found to exist, then more time was required for the specimens to reach the desired conditions, 'otherwise the calibration procedure could proceed as shown in Figure 9. Under conditions of uniform moisture content, specimens' weights are determined, and moisture content values (using Delmhorst meter), and the resistance of each moisture pin pair were obtained. The calibration curve, for which moisture content was correlated to resistance measurements, was derived using 15 square OSB specimens of the same type and thickness as that used in the mid-scale experiments.

3 PREPARATION OF TEST SPECIMENS

3.1 Preconditioning

Specimens were immersed in a water bath (Figure 10) for a period of 5 days in order to saturate the specimens. Aluminum angles of 1-m length are used to separate the stacked specimens from one another and from the bottom of the immersion bath to insure that water was in contact with all surfaces of the OSB specimens. This helped hasten the process of saturating the samples. Given that the fully immersed specimens had a tendency to float, bricks were placed on the upper most specimens to weigh these down and insure that these were kept submerged. After five days, water in the bath was drained and the specimens then remained in the bath for another two days to allow moisture to redistribute itself evenly within the OSB. The boards were prevented from drying out by sealing the bath lid with adhesive tape. Following this two-day period, each sample was then removed and moisture content measurement taken with a Delmhorst moisture meter. Weights as well as specimen thickness

were recorded for each specimen. The readings were used to determine if the moisture distribution in the specimens was reasonably uniform. Specimens would, upon removal from the bath, immediately start to lose moisture to the surrounding air. Hence in order to maintain specimens at close to saturated conditions and minimise the loss in moisture prior to the start of the experiment, specimens were assembled as quickly as possible.

3.2 Specimen assembly

Specimen assembly, in instances where results were being sought for OSB in combination with any of the membrane types, consisted of wrapping the sheathing with the membrane, setting the moisture pins to their predetermined locations on the board, affixing the specimen to the load cell and thereafter, connecting each pin pair to the D/A lead. Mid-scale experimental sets, related test conditions and materials combinations are presented in Table 2.

4 TEST CONDITIONS

Boundary conditions for the experiment are provided in Figure 11 and 12. Figure 11 shows the recorded temperature and relative humidity for the first set of experiments that were completed over a period of 30 days. Figure 12 likewise shows the recorded temperature and relative humidity for the second set of experiments conducted over a period of 21 days. The initial conditions are the temperature, the relative humidity and the total moisture content. As shown in Figures 11 & 12 (chamber conditions for Set I & II), the temperature and the relative humidity are nominally constant.

5 EXPERIMENTAL SETS

Two sets of experiments were conducted, each set consisting of nine specimen assemblies, a list of which is provided below in Table 2. Each of the assemblies was prepared according to the general procedures provided in the preceding sections. They were then placed in the environmental chamber at conditions of $23 \pm 0.5^\circ\text{C}$ and $30 \pm 3\%$ RH for a period of 30 days for the first set and 21 days for the second. Both sets of specimens were mounted in the weighing system and their weights were monitored on a continual basis using the Z-100 load cells connected to a HP data-logger (Figure 1). Conditions in the chamber were recorded using a "Smart reader" and data was "downloaded" from the device once the experiment was completed. Moisture contents of

the OSB boards was determined on a continuous basis together with gravimetric data as total moisture content; and local moisture content was measured through moisture pins placed in various locations of the different specimens.

6 RESULTS AND DISCUSSION

Nominal results for these mid-scale experiments are provided in Figures 13 to 23 for set I and in Figure 24 for set II. They include the weights of individual specimens together with resistance measurements taken across each of moisture pin pair as a function of time. For this study, hygIRC [Maref et al, 2002a and b] was used to estimate the drying response of nine specimens of OSB. The total moisture content as function of time of the nine (9) specimens, as determined by gravimetric analysis, is provided in Figure 13. Results for one of these specimens (No. 4) in which the hygrothermal response to drying at different pin pairs located in a single sheathing of OSB board is given in Figure 14. Figure 14, shows a comparison between simulated and measured total MC of the OSB board (per 0.8 meter of specimen width) as a function of time for specimen 4. The total MC in the system initially is ca. 70 % and after 30 days it reaches a value of 7%. Figure 15 shows a comparison between simulated and measured total MC of the OSB board as a function of time for specimen 5. The total MC in the system initially is ca. 58 % and after 30 days it reaches a value of 5%. Figure 16 provides the simulated and experimental drying results for OSB boards wrapped on both sides in membranes VII. The simulation curve in this figure follows the shape of the experimental data. The initial moisture content for OSB was 88%. The model predicts the same period of time to reach the equilibrium moisture content (6%). These results indicate a good agreement between results of simulation and those derived from experiment.

In general, the drying process is governed by the vapour permeability of the membrane. The higher the vapour permeability the faster the rate of drying in a given condition. The specimens were immersed in water for 5 days and then allowed to stabilize in an enclosed environment (sealed tank). Although it was assumed this period of stabilisation would help assure that the initial moisture content at the start of the experiment was uniform through the thickness of the material, this was not the case in every instance. It was observed that after the period of stabilisation certain OSB specimens were, at times, wetter in certain parts of the board than in others, suggesting a

non-homogeneous wetting pattern. In those sets the moisture pins were installed in specimens 4, 5, 7, 8 and 9 (see Table 2).

Figure 17 shows the change in moisture content in relation to time (days) in OSB specimen 4 for each of the 8 moisture pin pairs installed at $\frac{1}{2}$ the specimen depth.

As is shown in this Figure, the bottom part of the specimen dries faster than the top. This was due to the air movement in the climatic chamber that is estimated to be 1 m/s. The OSB starts drying at a significant rate (change from 25.4% to 10% Moisture Content) after the second day of the experiment in location 8 whereas in location 2, a similar rapid drying rate only occurs after 7 days. After the 12 days, asymptotic values of moisture content are observed. Based on these data it can be stated that, in general, the rapid drying rate observed was adequately described by the response obtained from the moisture pins and the drying process can thus be reasonably well ascertained based on these types of measurements.

The change in moisture content in relation to time of moisture pins placed at $\frac{3}{4}$ the specimen depth in OSB specimen 5 is presented in Figure 18. Moisture contents at a given pin-pair location were determined by associating the resistance to a specific moisture content based on the resistance-MC calibration curve obtained from previous experiments. Figure 19 shows the change in resistance ($M\Omega$) in relation to time (Days) in OSB specimen 5 for each 8 moisture pin pairs installed at $\frac{3}{4}$ the specimen depth. Three phases can be observed in this figure:

- The first phase occurs between 0 and 5 days;
- The second between 5 and 15 days; and
- The third between 15 and 27 days.

After 5 days of drying all moisture pins returned to a high value of resistance indicating lower moisture content. Figure 20 shows the first stage of drying. In phase 2, the resistance changed rapidly from 360 $k\Omega$ to almost 5 $M\Omega$ (i.e. 25.8 % to 15.2 % MC). After 10 days the curve continues slightly and a value of 280 $M\Omega$ (11.0 % MC) is obtained. After the 15th day, asymptotic values of resistance are observed; all the values lie between 280 $M\Omega$ and 320 $M\Omega$ (i.e. between 11.0 % and 10.6 % MC). Based on these preliminary data it can be stated that, in general the rapid drying rate observed was adequately described by the response obtained from the moisture pins and the drying process can thus be reasonably well ascertained based on these types of measurements.

Results are similar to those obtained for specimen 4: the lowest MC, i.e. the maximum resistance, is reached after 15 days of drying. These results fur-

ther indicate that the process of symmetrical drying of wetted OSB proceeds very rapidly in the initial stages (i.e. first 5 days of drying) and thereafter, the rate of drying diminishes significantly. Results obtained for drying of wetted OSB wrapped with membranes (VII, III, and V) are presented in Figures 21, 22 and 23 respectively. Figure 21 provides the change in resistance in relation to time, as measured across the moisture pins when installed at $\frac{1}{2}$ the depth of specimen No. 7. In comparison to the previous results obtained for OSB not wrapped with membrane, the rate of drying is evidently lower. For specimen 7, the surface of OSB is not in direct contact with air; hence water vapour must diffuse through the membrane, which necessarily reduces the drying rate. Membrane VII has lower vapour permeability than the OSB and is also the least permeable. Similar remarks can be offered regarding the results presented in Figure 22, which represents the moisture content in relation to time of 6 moisture pins installed at $\frac{1}{2}$ the OSB thickness of specimen 8 wrapped in membrane III. The drying rate is slower than the previous specimen and the reason for this is straightforward: the vapour permeability of membrane III is the lowest among the membranes tested and so is the least permeable amongst them. Hence the drying of OSB wrapped with this membrane evidently would take more time to reach the EMC than OSB wrapped membrane VII.

Figure 23 represents the moisture content in relation to time of the 6 moisture pins installed at $\frac{1}{2}$ the OSB thickness in specimen 9 wrapped in membrane V. The OSB Sheathing did not dry completely after 30 days of experiment such as the top part of it that still wet. Because of the low vapour permeability of membrane V, the drying rate is slower than the previous specimens. Hence the drying of OSB wrapped with this membrane evidently would take more time to reach the EMC than OSB wrapped membrane with membranes III and VII.

The total moisture content as function of time of the nine (9) specimens of the set II, as determined by gravimetric analysis, is provided in Figure 24. The drying process in set II is similar to the previous set. The higher the vapour permeability the faster the rate of the drying in a given condition.

7 CONCLUSIONS

Experimental work has been done to help benchmark an advanced hygrothermal model called hy-IRC. This paper reported on experiments undertaken under symmetric drying conditions - i.e. both

major surfaces of the test assembly were exposed to the same environmental conditions. Additional experiments on one-sided drying conditions will be reported in the future. This will further enhance confidence towards the implementation of hygIRC to undertake broader parametric studies. The overall agreement between experimental and simulated results is very good in terms of the shape of the drying curve and the time taken to reach equilibrium moisture content.

The results presented offer an overview of the work carried out on mid-scale drying experiments. This work gives a good combination between the experiment and the simulation. It gives us a better understanding of the behaviour of specimen when they are subjected to different climatic conditions. The experimental results presented in this paper give not only the bulk moisture content of the OSB with different assembly, but also the local moisture content. The most apparent observation is that the moisture pins provide quantitative information on the moisture content of the OSB in each zone over the time the drying experiment is conducted. Another noteworthy observation is that in mid-scale experiments the effect of the membrane on the drying process is quite evident: OSB wrapped with membrane will necessarily dry slower than the OSB alone.

8 ACKNOWLEDGMENTS

Thanks are extended to Mr. Daniel Perrier for setting-up and undertaking the experiments and Mr. Raymond Demers and Yvon Tardiff for the preparation of the moisture sensors.

9 REFERENCES

- Maref (a), W., Lacasse, M. A., Kumaran, M. K., Swinton, M. C. 2002. Advanced Hygrothermal Model-HygIRC: Laboratory Measurements and Benchmarking", Proceeding of the 12th International Heat Transfer Conference (18-23 August 2002, Grenoble, France)
- Maref (b), W., Lacasse, M. A., Kumaran, M. K., Swinton, M. C. 2002. Benchmarking of the Advanced Hygrothermal Model-hygIRC with Mid Scale Experiments", Proceeding of the eSim Conference-IBPSA-Canada- Montreal (Sept. 12-13, 2002).
- Maref (c), W., Lacasse, M. A., Booth, D., Nicholls, M. & O'Connor, T. 2002. Automated weighing and moisture sensor system to assess the hygrothermal response of wood-sheathing and combined membrane sheathing wall components. Pro-

ceeding of the 11th Symposium for Building Physics, Dresden, Germany, 2002.

Table 1 -Physical property of materials

Material	Dry Density (kg/m ³)	Thickness (mm)
OSB	650	11.5
II	810	0.21
III	870	0.23
IV	800	0.35
V	715	0.72
VII	464	0.14
X	670	0.10

Table 2 –Mid-scale experimental sets and related material combinations

Set No.	Spec. No.	Materials
1	1	VII + Wet OSB + VII
	2	III + Wet OSB + III
	3	V + Wet OSB + V
	4	Wet OSB + MP @ 1/2 D
	5	Wet OSB + MP @ 3/4 D
	6	Wet OSB + NO MP
	7	VII + Wet OSB + VII
	8	III + Wet OSB + III
	9	V + Wet OSB + V
2	1	II + Wet OSB + II
	2	X + Wet OSB + X
	3	IV + Wet OSB + IV
	4	Wet OSB + MP @ 1/2 D
	5	Wet OSB + MP @ 3/4 D
	6	Wet OSB + NO MP
	7	II + Wet OSB + II
	8	X + Wet OSB + X
	9	IV + Wet OSB + IV

- Membranes II, III, IV and V are respectively Asphalt impregnated building papers 10 min, 30 min, 60 min and 15 # felt.

- Membranes VII & X are polymer-based spun bonded polyolefin.

Figure 1 Weighing system for monitoring changes in MC of oriented-strand board (OSB) specimens

Figure 2 Sorption curve for oriented-strand-board (OSB) – MC as a function of % RH

Figure 3 Sorption curve for sheathing membranes II, III and V– MC as a function of % RH.

Figure 4 -Sorption curves for sheathing membranes VII and X– MC as a function of % RH.

Figure 5 - Vapour permeance (x-direction) of oriented-strand-board (OSB) and membranes II, III, V, VII and X

Figure 6– Schematic of the Data Acquisition set-up

Figure 7— Moisture pins inserted in OSB sample

Figure 10 – Mid-scale samples in soaking bath

Figure 8 - Pre-conditioning of OSB Samples

Figure 4 - Calibration of the Moisture Pins on the OSB

Figure 11- Boundary conditions for the experiment showing the recorded temperature (T) and relative humidity (RH) in the climatic chamber as a function of time conducted over 30 days

Figure 13- Total moisture content as function of time of 9 test specimens determined by gravimetric analysis for Set 1

Figure 16 - Total moisture content as function of time of OSB layer wrapped on both sides with membrane VII (Experiment / Simulation)

Figure 14- Total moisture content as function of time of OSB layer – specimen 4 (Experiment / Simulation)

Figure 17– Local moisture content of specimen 5 (OSB only)

Figure 15- Total moisture content as function of time of OSB layer – specimen 5 (Experiment / Simulation)

Figure 18- Local moisture content of specimen 4 (OSB only)

Figure 19 Resistance Vs Time for specimen 4, from 0-27 days

Figure 22 - Local moisture content of specimen 8 (OSB wrapped with membrane III)

Figure 20 Resistance Vs Time for specimen 4, from 0-10 days

Figure 23 - Local moisture content of specimen 9 (OSB wrapped with membrane V)

Figure 21 - Local moisture content of specimen 7 (OSB wrapped with membrane VII)