Impact of Weather on Predicting Drying Characteristics of Spray-Applied Cellulose Insulation

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ABSTRACT

The built-in moisture in spray-applied cellulose fiber insulation (CFI) can significantly affect the hygrothermal performance of residential wood frame walls. In this application, CFI is installed in wet or damp form with water or adhesives used as bonding agents. Interior finishes are often installed without adequate drying time. In cold weather, particularly in north-facing walls, drying times may be much longer than anticipated.

Hygrothermal response of wood-framed walls after installation of spray-applied CFI was investigated using a combined numerical and experimental approach. A test hut study was undertaken in the mixed-humid climate of northern Georgia, and hygrothermal modeling was also carried out. The test results show that walls with spray-applied CFI dry out longer than anticipated. The accuracy of the predicted results was found to depend on inclusion of infrared radiation effects in the simulation. Additional simulations were performed for installations completed at different times of the year in the cold Detroit, Michigan, climate and in the hot San Antonio, Texas, climate. The results indicate that drying rates are dependent on time of year when the spray-applied CFI is installed, particularly in colder climates. In cold weather, and in north-facing walls, the drying rates can extend for months. When spray-applied CFI is installed in January, moisture conditions near the sheathing can remain at high levels well into the spring, although moisture conditions closer to the interior decrease more rapidly. Moisture content measurement of the insulation during the drying period from the building interior using moisture meters may not detect the elevated moisture conditions that exist near the exterior sheathing. With vapor tight exterior sheathing, the walls are not capable of drying inward unless the indoor partial pressure of water vapor is below that in the insulation.

INTRODUCTION

Spray-applied cellulose fiber insulation (CFI) may contain substantial quantities of built-in moisture. Typical recommended moisture contents vary between 30% and 40% by weight. However, it is not uncommon to find installations where moisture content exceeds these levels. Following the installation of CFI, the walls are kept open for a period of time prior to the installation of interior finishes (i.e., gypsum wallboard and paint). A twenty-four-hour period is the minimum time recommended by the industry to accommodate drying of CFI. This period is typically inadequate to provide sufficient drying. If the insulation is still wet, this built-in moisture can lead to performance related problems in walls. Several manufacturers recommend forty-eight hours as a minimum drying period. Very few CFI manufacturers provide additional drying guidelines for the period when the CFI is exposed, such as lowering indoor relative humidity (RH) (by ventilating the building in cool or cold weather or by use of dehumidification equipment) or using electric heaters to increase temperature in the building

This paper focuses on a factor that affects the drying rate of spray-applied CFI, specifically the time of year when the installation is completed. Based on the results of prior research (Babineau and Bianchi 2007; Burnett et al. 2004), weather, specifically outdoor temperature, is an important factor affecting the drying rates.

FIELD DRYING EXPERIMENT

A drying experiment was performed in a test hut in the mixed-humid Georgia climate. The hut was built in October 2008 and instrumented with sensors and data-acquisition

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systems in mid-December. Spray-applied CFI was installed January 8, 2009. The test hut was not heated; this was consistent with homes under construction, which are typically unconditioned. The test hut was constructed to include multiple test wall assemblies. Test walls measured 8×9 ft. The interior of the test hut was divided into two rooms. Four wall sections (all in one of the two rooms) were filled with CFI sprayed by certified applicators using normal procedures. In four wall sections (all in the other room) the same applicators installed spray-applied CFI in a modified manner (i.e., higher moisture content), specifically by increasing the water pump pressure of the application equipment. This was thought to mimic what may occur with an inexperienced applicator. All wall sections were oriented to the north. North orientation has been found most severe in terms of drying of walls (i.e., slowest drying rates and longest drying periods). The low amount of solar radiation that north-facing wall surfaces receive results in lower average wall temperatures than in south facing walls. The lower temperatures lead to lower drying rates. Framing members in the test wall sections were 2×4 studs spaced 24 in. on center. The wall sections were filled to full cavity depth with spray-applied CFI. Wall sheathing was 7/16 in. thick oriented strand board (OSB) and was covered with a water resistive barrier membrane. A different membrane for each of the four walls with insulation installed at nominally the same moisture condition. No cladding system was present. This was felt to be representative of the typical state of wall completion when walls are insulated in normal construction practice.

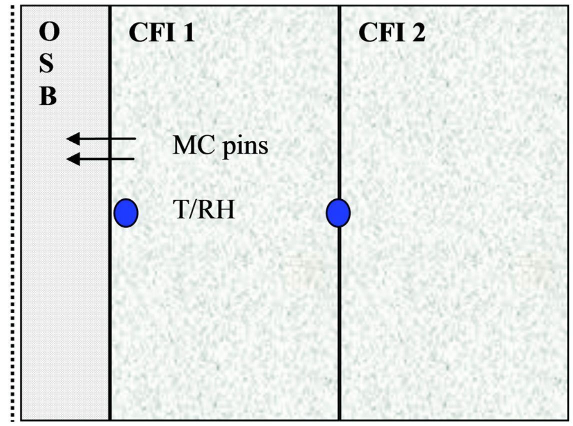


Figure 1 *This figure shows the schematic cross section through the wall and the locations at which continuous measurement were taken. Layers start from exterior climate side on the left: polymeric water resistive barrier, OSB sheathing, and cellulose insulation. Cellulose insulation was installed as one layer, but for reference purposes it is shown as two layers. Moisture content pins were inserted into OSB, and temperature/relative humidity sensors were at full and mid-depth of the cellulose insulation.*

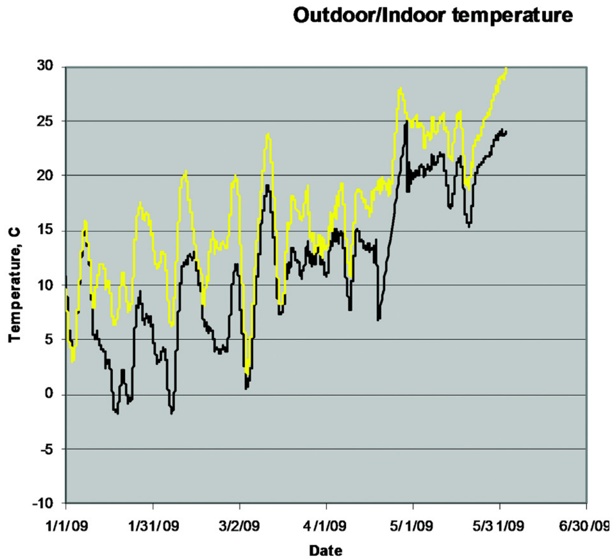
During the installation of the spray-applied CFI, gravimetric samples were taken to measure as installed moisture content in the insulation. Samples were sprayed into a bag, the bag was sealed to prevent evaporation, and the weight of the samples was recorded. The insulation was first dried at low humidity conditions (at about 30% RH) and then oven dried at 103°C (217°F). As-installed moisture content and equilibrium moisture content at 30% RH were calculated using the weights obtained prior to and following the drying. The equilibrium moisture content at 30% RH was found to be about 6% by oven-dry mass. The dry density of the installed insulation was also determined by cutting a known size sample of insulation from the walls (6×6×3-1/2 in.) and weighing the samples after drying.

The walls were instrumented for temperature and RH at mid-wall thickness and at the insulation-to-sheathing transition. Moisture content pins were inserted in the sheathing. The location of sensors is shown in Figure 1. Plugs from the OSB sheathing were obtained 1 and 5 months after installation of the CFI for gravimetric determination of moisture content. These measurements indicated average moisture content through the full OSB thickness.

Interior and exterior temperatures and RH were monitored and used as boundary conditions when simulating the drying performance with a hygrothermal model. A weather station approximately ten miles away collected weather parameters such as temperature, RH, wind speed and wind direction, rain, and solar radiation. Indoor and outdoor temperatures and RH are shown in Figure 2. Data recording began on January 1, prior to installation of the spray-applied CFI. Winter weather in Georgia is mild, although there were nights and days when the ambient temperature fell below freezing (Figure 2). Interior temperature moved in response to outdoor temperature, although it typically exceeded it by a few degrees. This was not unexpected; temperature in enclosed unconditioned structures typically exceeds ambient temperature as a result of solar heating. During the first few days following installation of the spray-applied CFI, indoor RH generally exceeded outdoor RH, even though indoor temperature exceeded outdoor temperature. This indicates elevated indoor partial pressure of water vapor relative to outdoor ambient conditions, almost certainly from moisture release from the spray-applied CFI. Over roughly one month's time, indoor RH levels became similar to outdoor RH levels, and as time progressed further they fell below outdoor levels. The indoor RH data shown in Figure 2 is for the room in which the spray-applied CFI was installed with the application equipment run in its normal mode.

Installation Effects

The as-installed moisture content of spray-applied CFI installed according to "normal practice" approached 70% by



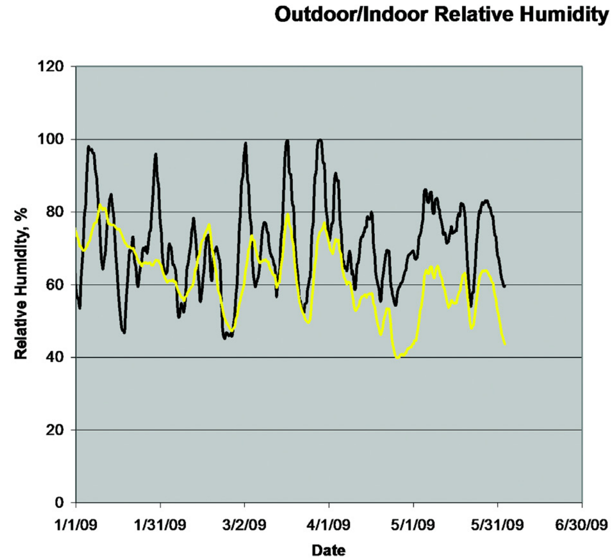


Figure 2 *Daily average outdoor and indoor temperature and relative humidity values in the field test. Black and yellow lines show outdoor and indoor conditions, respectively.*

Table 1. Installed Moisture Content (% by Weight) and Dry Density

Application Method	Moisture Content, % weight
Asked to Install as "Normal"	
Sample 1	66%
Sample 2	67%
Sample 3	71%
Average dry density	56 kg/m^3 (3.5 lb/ft^3)
Asked to install as "Wet"	
Sample 1	86%
Sample 2	100%
Sample 3	112%
Average dry density	71 kg/m^3 (4.5 lb/ft^3)

Note: Three samples were taken in each room (half of the test hut) at the beginning, the midpoint, and the end of the spraying.

oven-dry mass, substantially in excess of the 40% level recommended by the manufacturers (Table 1). Spray application of CFI results in consistent volumetric filling of cavities, suggesting that the installation method results in predictable and efficient use of the insulating material. However, it was found that installed density was related to as-installed moisture content (Table 1, Figure 3). It may thus be expected that if as-installed moisture content is not well controlled, installed density may be variable. This may result in less-than-efficient use of material (i.e., greater quantity of insulation used), which will increase the installation cost. Furthermore, if spray-applied CFI is installed at elevated moisture content, its accompanying elevated installed density will result in a further increase in the amount of water that is introduced into the volumetric space of each insulated cavity. For instance, with the dry density 40% greater and moisture content (by oven-dry mass) 50% higher than recommended, the volumetric moisture content (or moisture content per wall area) is $1.4 \times 1.5 = 2.1$ times the recommended level. Higher moisture content in the as-installed CFI requires longer drying, leads to higher as-installed density (Table 1 and Figure 3) and greater quantity of material used.

Comparing Measured and Simulated Drying

Simulations (Karagiozis and Künzel 2001) of drying experiments were carried out to compare measured and predicted hygrothermal response of the wall assemblies.

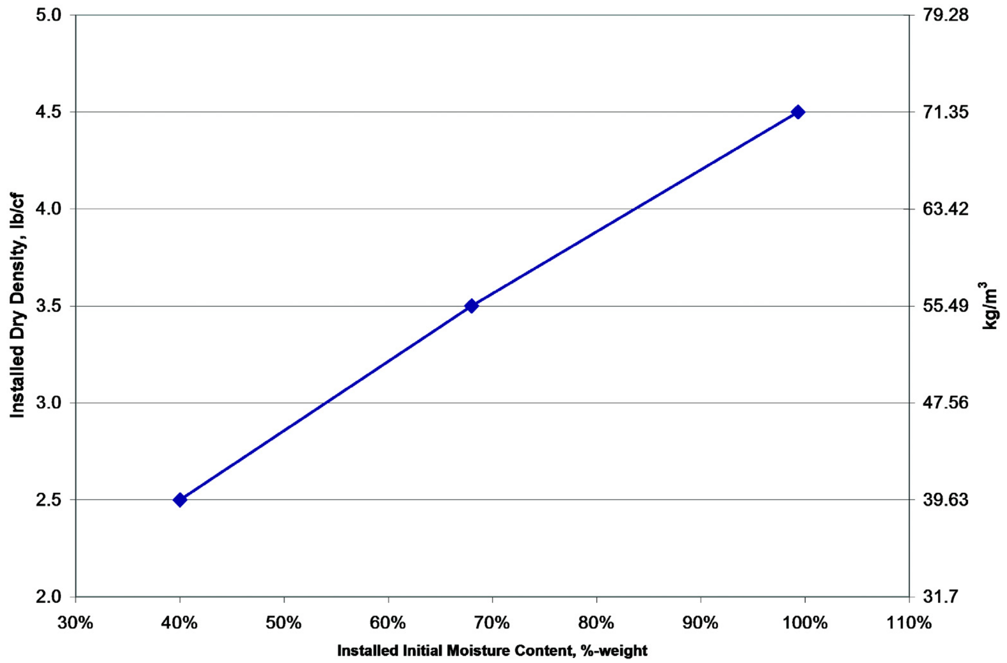


Figure 3 *Initial moisture content of the damp sprayed cellulose insulation at the time of installation and the resulting dry density of the insulation. The first point (40% moisture content) has been taken from the manufacturer recommendations (2.5 lb/ft^3 and max. 40% moisture content per weight).*

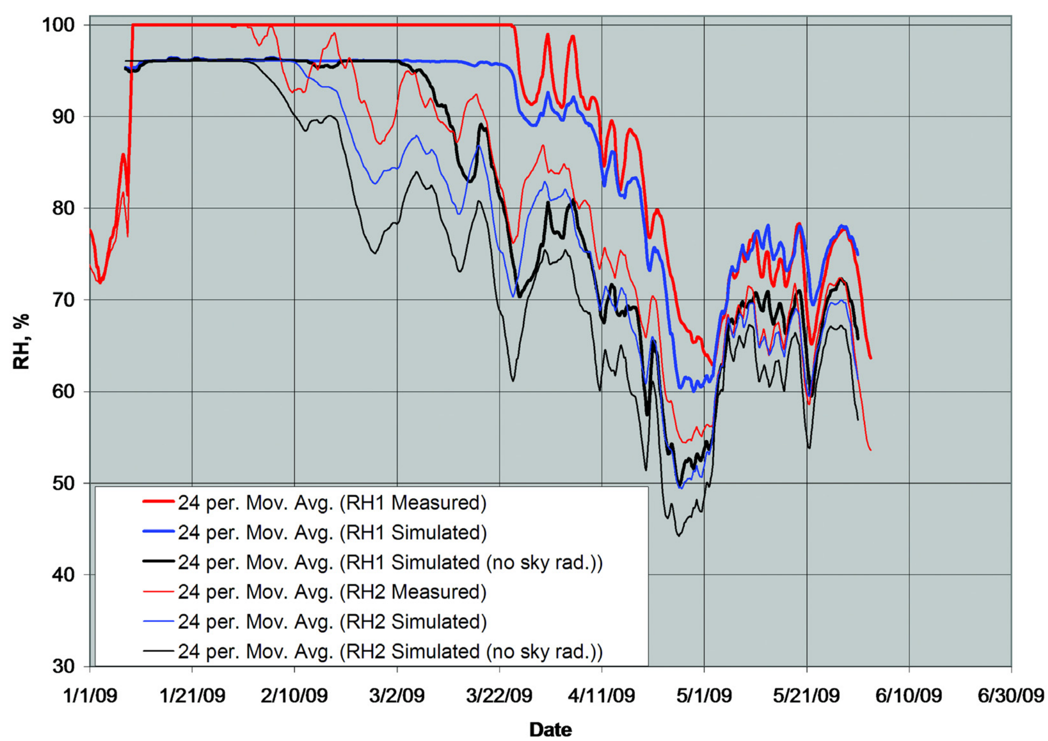


Figure 4 *Measured and simulated relative humidity on the interior surface of the exterior sheathing (RH1) and at the mid-depth of the cellulose insulation (RH2). Simulation results without sky radiation (no sky rad.) did not include radiation balance of the walls with the environment.*

Figure 4 shows both simulation-predicted and measured RH in the cellulose insulation, plotted as a function of time. The results show good agreement between measured and predicted RH in the CFI, provided that the simulation includes the effect of longwave (infrared) radiation. The plots show substantially the same time trends in predicted and measured values but with some systematic differences between values. The difference in RH is on average 3% to 4%, with few periods peaking at 7% to 8%. The simulation predictions and the experimental measurements each indicate that drying occurs more rapidly at mid-thickness of the insulation than near the inboard surface of the exterior sheathing. Measured conditions near the inboard surface of the sheathing stayed at constant 100% RH for approximately 2-1/2 months before decreasing, whereas at center-thickness of the insulation, measured RH stayed at 100% for approximately 1 month.

Predicted RH at either of the locations did not reach 100% but reached well in excess of 90% and remained elevated for an extended period. The simulation results show that the period of elevated RH was substantially longer near the inboard surface of the exterior sheathing than at center thickness of the insulation and in concurrence with the experimental measurements. The moisture content gradient that develops across the depth of the insulation suggests that measurements obtained in the insulation from the building interior with a capacitive reactance type meter, as recommended by the trade association (CIMA 2010), are not likely to detect the elevated conditions. Elevated moisture content prevails in the outboard layers of the insulation near the exterior sheathing in north-facing walls insulated during the winter (even in the mild mixed-humid climate of northern Georgia).

It should be noted that the as-installed moisture content of the insulation in this wall (at approximately 70% dry mass basis) was substantially higher than recommended by the manufacturer, but as stated previously, the installation was performed by a professional applicator following their normal practices. During the drying period indicated in Figure 4, gypsum wallboard was not installed, and a cladding system was also absent. This configuration provided an optimal condition (i.e., the least resistance to water vapor transport) for dissipation of the moisture introduced into the wall cavity during the installation of spray-applied CFI, at least for a wall with low permeance OSB sheathing.

As indicated previously, agreement between predicted and experimental results was dependent on inclusion of sky radiation in the simulation. Excluding the effect of heat loss to the cold sky results in higher predicted sheathing temperatures than measured experimentally. With the inclusion of sky radiation in the simulation, the temperatures matched well. The predicted temperature of the sheathing affected the predicted drying rate (Figure 4). This highlights the importance of including accurate boundary conditions in simulations.

The moisture content of the OSB sheathing measured with moisture pins, measured gravimetrically, and predicted by simulations is shown in Figure 5. The predicted and gravimetric measured (oven dry) moisture contents match well. The gravimetric measurement made five months after installation of the CFI also matched the moisture pin measurements. In contrast, the gravimetric measurement made one month following installation of the CFI yielded a value more than 5% lower than the measurements made with moisture pins (but in close agreement with the numerically predicted value). The moisture content obtained with moisture pins made in early February thus appears high. Simulation results (not presented in this manuscript) show that a moisture content gradient would have been present across the thickness of the OSB in early February, with low moisture content in the layers near the exterior, and high moisture content in the layers close to the insulation. This gradient would be expected to influence moisture content measurements made with pins (which generally are dominated by more conductive layers). The initial moisture content in the simulations was 70%, as in the test hut experiment, and 40% as recommended by some cellulose manufacturers as the maximum installed moisture content. The high as-installed moisture content in the CFI (i.e., 70% by dry mass) resulted in only slightly higher moisture content in the OSB than did the recommended maximum level (of 40%) but extended drying time of the OSB in the spring by approximately two weeks.

TIME OF YEAR INSTALLATION IN A COLD CLIMATE

A series of twelve simulations were carried out to examine the effect of the time of year when the spray-applied CFI insulation was installed. North facing 2×6 walls with the spray-applied insulation installed at recommended moisture content were modeled with Detroit, Michigan, climate. Each simulation modeled a drying period of one month, with the start of each period on the first day of the month. The simulation model used was the same model validated with experimental data in Georgia, and the effect of long-wave radiation was included in the simulation runs. The year of weather data from which each monthly set of outdoor conditions was derived for the simulations is shown in Figure 6. Interior temperature was set to a minimum 40°F and followed the outdoor temperature trend with a 5°F higher increment. The interior conditions were well ventilated with outdoor air and represented low moisture loads in the interior. The modeled wall assemblies consisted of the same components as those modeled in Georgia, but the thickness of the insulation layer was increased to be consistent with 2×6 wall construction. The indoor conditions during drying can vary greatly and will depend on whether installers follow manufacturer recommendations. Typically, manufacturers recommend the use of a heater (preferably electric heaters) for installations completed in cold weather (i.e., at temperatures at or below 40°F) and request provisions for ventilation of the building interior to remove moisture that builds up in the space. To replicate these conditions, the mechanical system parameters in the simulations were set to "heating mode only" (no humidification) with 40°F temperature setpoint and ventilation rate of two air

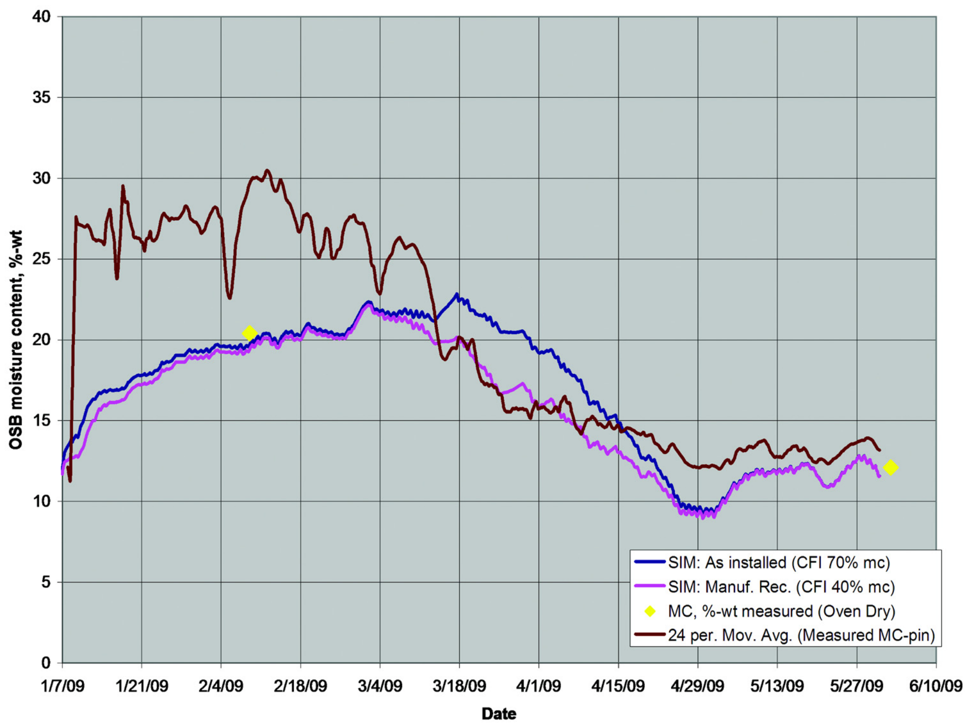
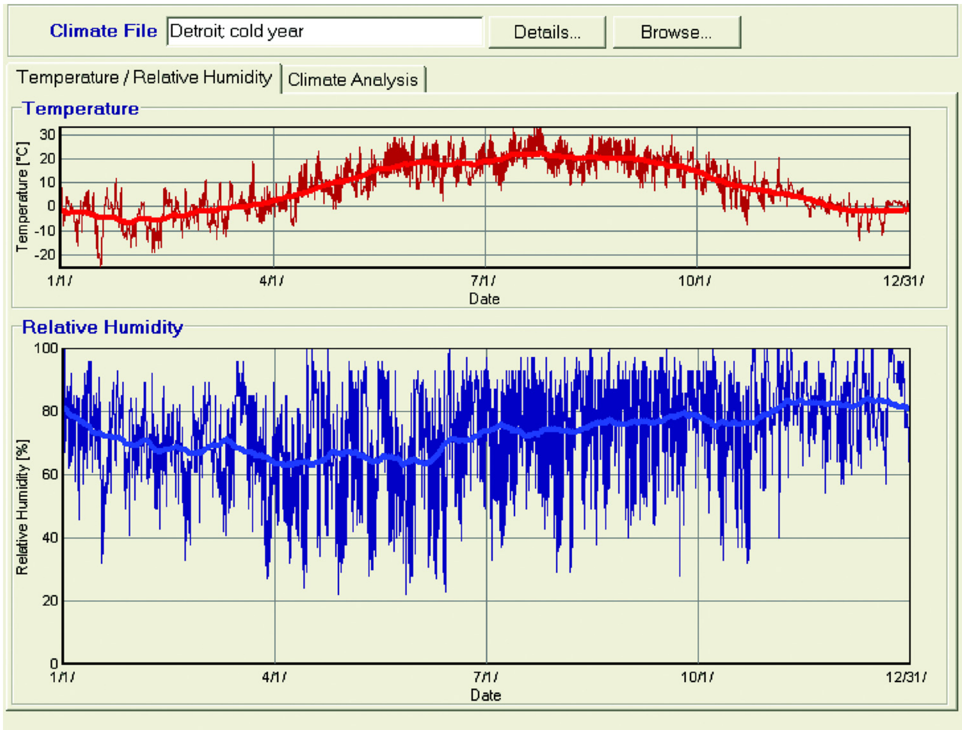


Figure 5 *Measured moisture content (with moisture pins) of OSB in the test hut wall after installation of damp sprayed cellulose insulation. Simulation results with two different initial moisture contents (40% and 70% by weight), as well as results from moisture content samples (yellow squares), are also shown.*

changes per hour (ach). This setup assumed a well-ventilated house having almost the same indoor and outdoor absolute humidity. This minimizes the possibility of indoor climate as the source of moisture leading to accumulation in the walls. The as-installed moisture content was set to equilibrium with 80% RH in all assembly components except the CFI. Moisture content in the CFI was set to 40% by dry mass (i.e., with CFI density equivalent to 40 kg/m^3; this implies adding 16 kg/m^3 of water), which is the upper limit of the manufacturers' recommended as-installed moisture content.

Drying of the walls during the month following installation of the spray-applied moisture conditions in the CFI over a month-long drying period was affected by the time of year when the installation was completed. Temperature limits the maximum available saturation water vapor pressure and thus controls the vapor movement and condensation. Indoor climate can either be a sink (i.e., allowing for drying) or a source for the accumulated moisture in the walls. For example, the exterior sheathing or the insulation layer closest to it cannot dry inward if the temperature in the exterior sheathing is below the dew-point temperature of the indoor air. Instead, the water vapor transfer occurs from the interior toward the building exterior. During cold weather, the available difference in partial pressure of water vapor is low due to the low saturation pressure (affected by the low temperature), and the drying rate is decreased. The average predicted moisture content of the (full thickness) OSB layer one month following the installation of the CFI is shown in Figure 7. The average moisture content plots for the outboard and inboard halves of the 5-1/2 in. thick insulation layer are shown in Figures 8 and 9, respectively. Figure 7 indicates that installation completed in cold weather can lead to increase in average moisture content of the OSB sheathing, as a consequence of moisture being transported in the direction of decreasing driving potential (i.e., from building interior to the exterior). Moisture content of the OSB sheathing increased progressively shortly after the installation of spray-applied CFI and in some cases exceeds 16%. The highest moisture content (of approximately 18%) is reached with the December installation. In contrast, for an installation completed on June 1, the moisture content peaks at approximately 13% within roughly a week of the installation, and thereafter begins to decrease.

Figures 8 and 9 show that a generally progressive decrease in moisture content of the insulation is predicted following the installation, with the decrease being distinctly more consistent and pronounced in the inboard half of the insulation than in the outboard half. The exception to this was moisture content in the outer half of the insulation layer for



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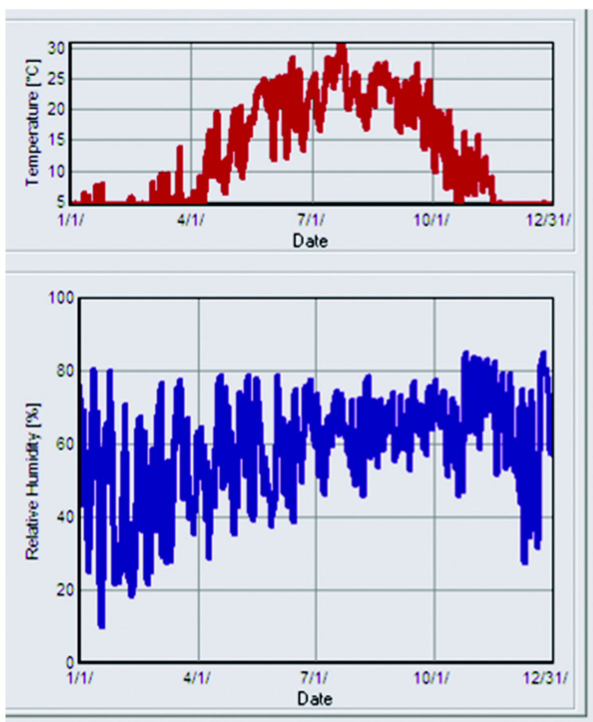


(b)

Figure 6 *Weather conditions (temperature, relative humidity) used in simulations for Detroit. The cold year is a year chosen from 30 years of weather data that has the third-lowest average annual temperature: (a) outdoor and (b) indoor.*

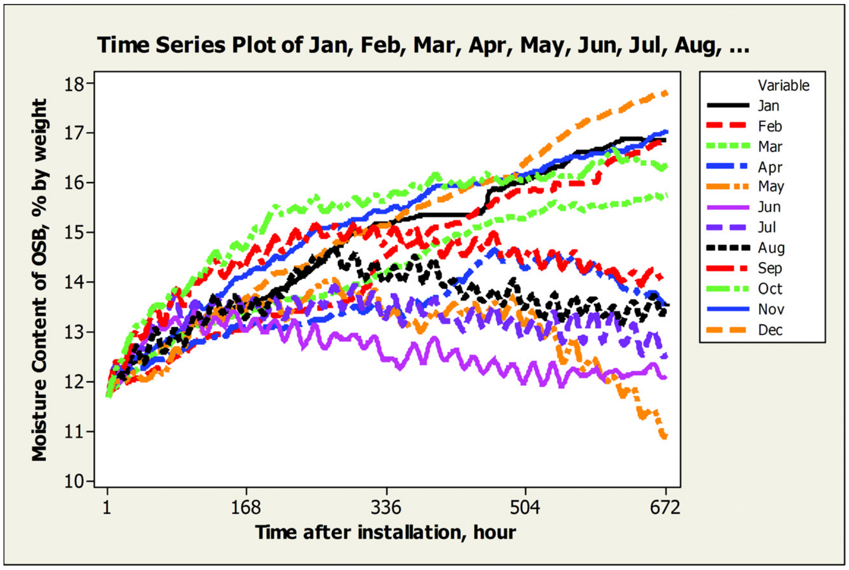


Figure 7 *The moisture content of OSB (average through the thickness) as a function of time (in hours) since the installation of damp sprayed cellulose. The installation occurred on the first of the month in Detroit, MI.*

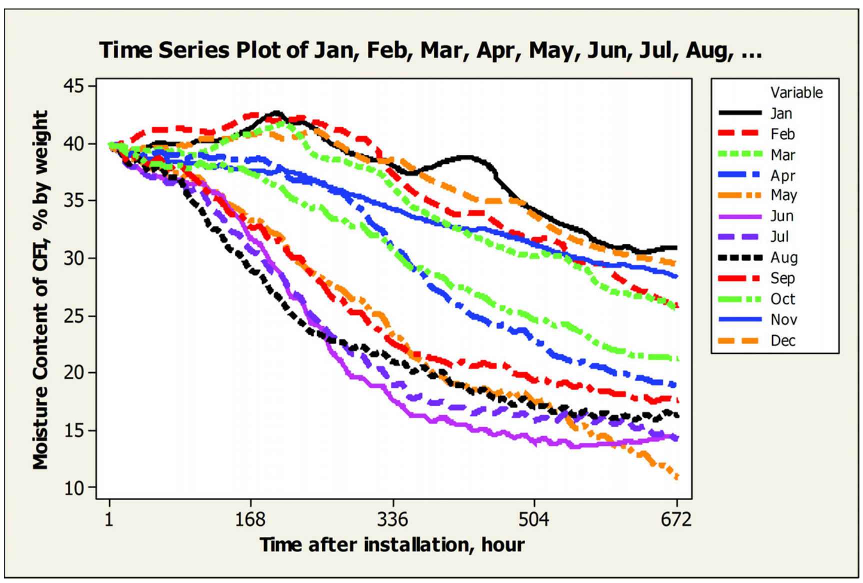


Figure 8 *The moisture content of CFI (average through the exterior facing half thickness) as a function of time (in hours) since its installation. The installation occurred on the first of the month in Detroit, Michigan.*

installations made between December and March. In installations made during these months, the predicted moisture content in the CFI in the outer half of the insulation layer increased by approximately 2% to 3% during the first week following its installation. During the subsequent three weeks, moisture content decreased, albeit at a slow rate. Although predicted moisture content in each half of the insulation layer decreases over the month-long drying period, the rate of drying is substantially slower in the outer half than in the inner half. For all months of installation, the moisture content in the inboard half of the insulation drops below 20% within one month after installation (Figure 9). In contrast, predicted moisture content in the outboard half of the insulation drops below 20% within one month after installation for installations made

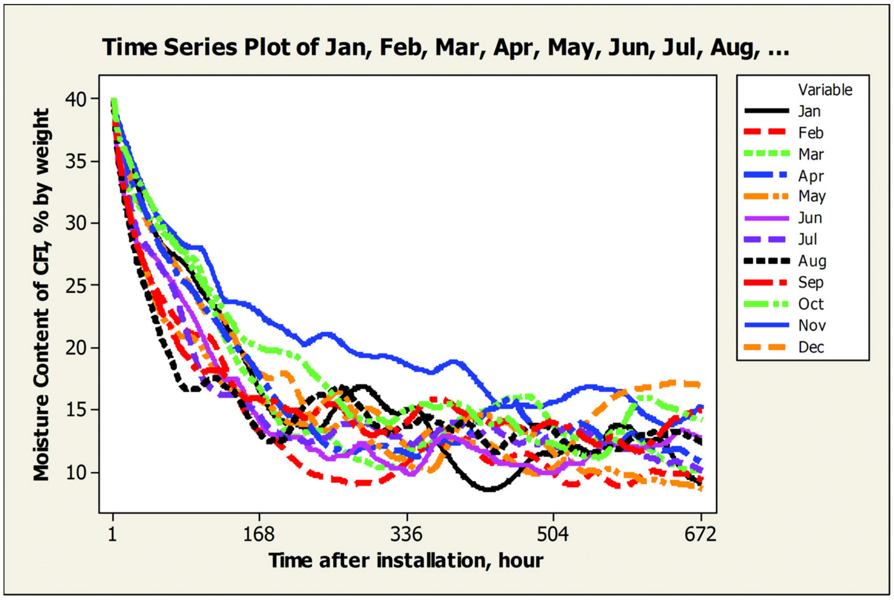


Figure 9 *The moisture content of CFI (average through the interior facing half thickness) as a function of time (in hours) since its installation. The installation occurred on the first of the month in Detroit, Michigan.*

only during the five warmer months of the year, May through September (Figure 8). In summary, the simulations indicate slow drying rates of the outer half of spray-applied CFI if it is installed in cold weather.

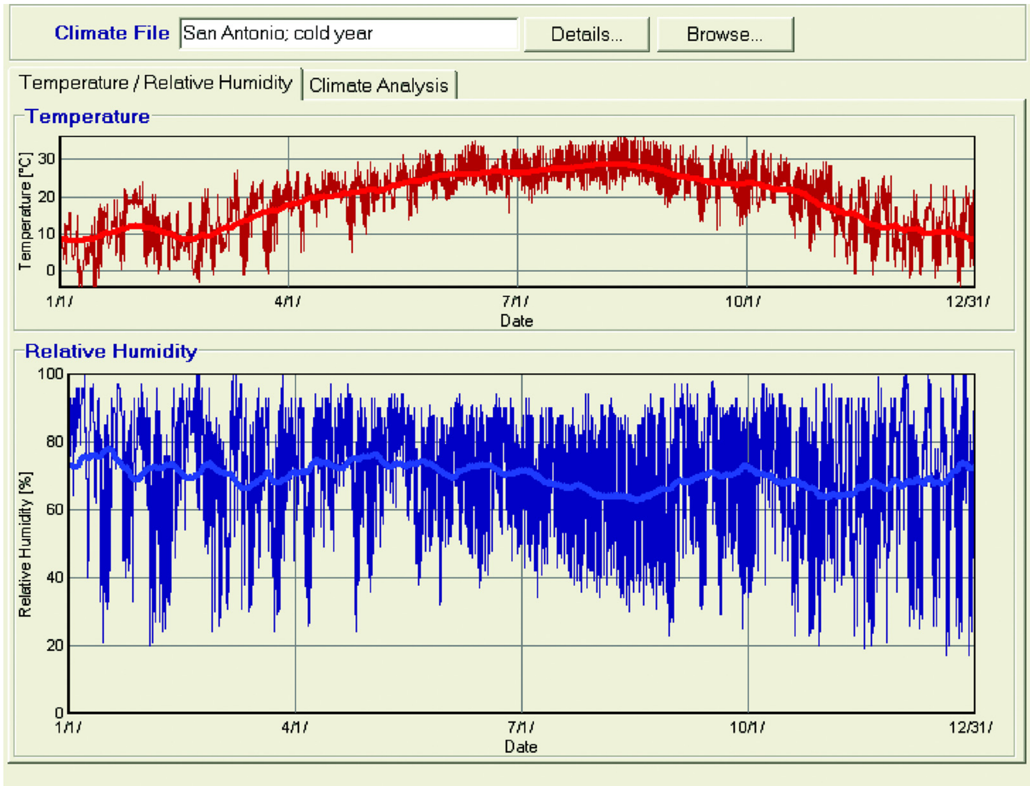
SPRAY-APPLIED CFI INSTALLED IN A HOT CLIMATE

The twelve simulations carried out with Detroit, Michigan, outdoor climate were repeated with San Antonio, Texas, weather data to examine the drying characteristics of spray-applied CFI in a hot climate. All simulation parameters were maintained unchanged with exception of the outdoor boundary conditions. The modeled wall assemblies consisted of the same components modeled in Detroit, Michigan, except that a 3.5 in. insulation layer was assumed. This was consistent with 2×4 wall construction, which is predominant in San Antonio. An as-installed CFI moisture content of 40% was also assumed. Again, each simulation modeled a drying period of one month, with the start of each period on the first day of the month. The yearly weather data from which each monthly set of outdoor conditions was derived for the simulations is shown in Figure 10.

Figures 11 and 13 show that a generally progressive decrease in the moisture content of the insulation is predicted following the installation of the spray-applied CFI. Immediately following its installation, moisture content increases for a period of several days, stabilizes, and begins the decrease. With the exception of CFI installed during the months of December and January, all remaining installations begin to dry out within the first week (Figure 11). Moisture content in the outboard half of the insulation predicted in simulations declines immediately following its installation and drops below 20% (by dry mass) within a two week period. In summary, the simulations carried out with San Antonio climate data indicate improved drying of the outer half of spray-applied CFI in comparison to CFI installed in cold climate/weather such as Detroit, Michigan.

MOISTURE CONTENT COMPARISON

An analysis was then undertaken that evaluated predicted moisture contents in the CFI one week after its installation, and the resultant moisture contents were plotted as a function of average weekly temperature. The analysis involved modeling of 2×4 walls in San Antonio, Texas, and Detroit, Michigan. Figure 14 shows the average moisture content of the CFI for the exterior half thickness of the insulation layer. In the warmer San Antonio climate, CFI dries out faster. In winter, the average weekly temperatures are above freezing (i.e., above 32°F [0°C]), and CFI installation showed a better drying performance. However, even in San Antonio, there were 3 months with average ambient air temperature below 50°F (10°C) during the week of drying. CFI installed during colder periods with average weekly temperature below 10°C moisture content remained above 30% for over a week. This demonstrated that even with more favorable climatic drying conditions, moisture content in the CFI could remain above the recommended levels longer than expected.



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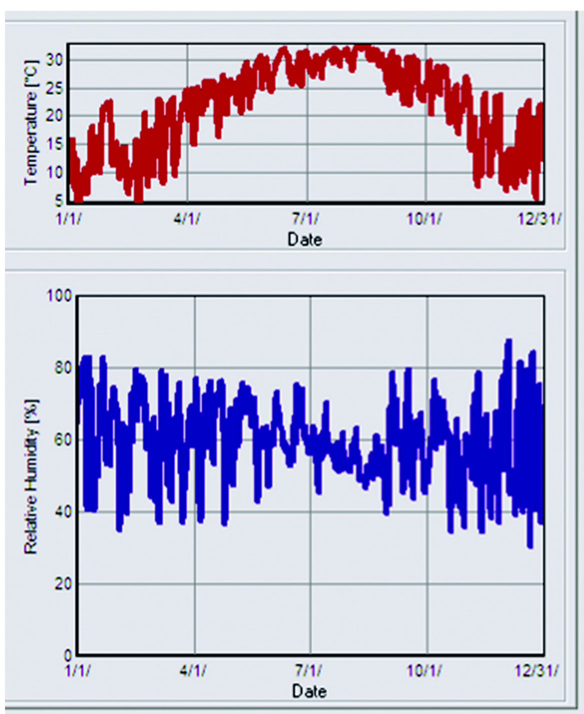

(b)

Figure 10 *Weather conditions (temperature, relative humidity) used in simulations for San Antonio. The cold year is a year chosen from 30 years of weather data that has the third-lowest average annual temperature: (a) outdoor and (b) indoor.*

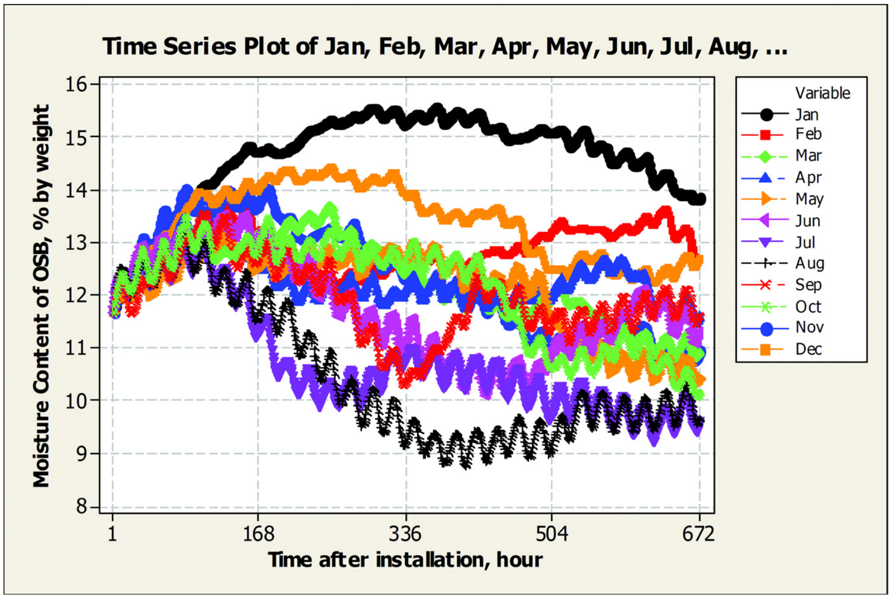

Figure 11 *The moisture content of OSB (average through the thickness) as a function of time (in hours) since the installation of damp sprayed cellulose. The installation occurred on the first of the month in San Antonio, Texas.*

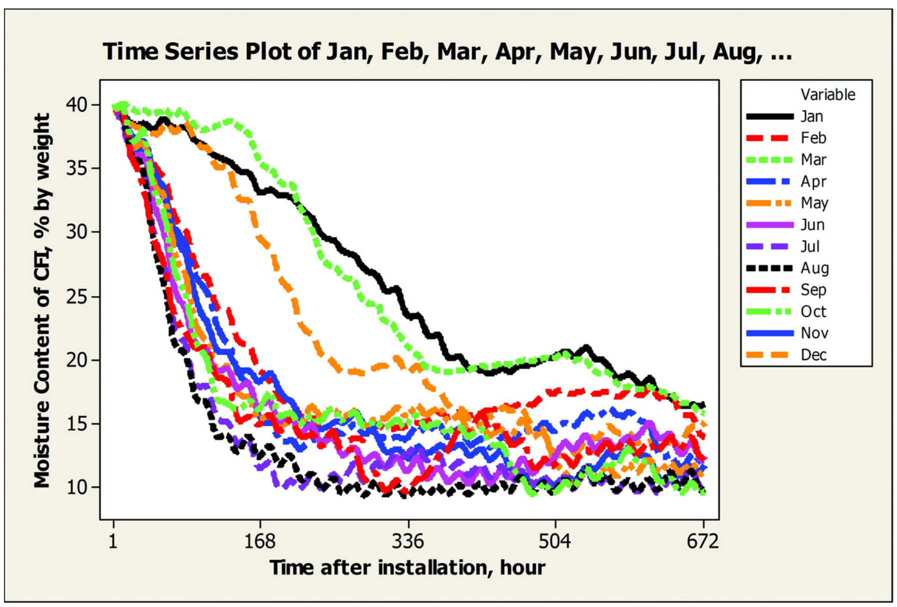

Figure 12 *The moisture content of CFI (average through the exterior facing half thickness) as a function of time (in hours) since its installation. The installation occurred on the first of the month in San Antonio, Texas.*

A final analysis was undertaken that also focused on moisture conditions at the end of one week's drying time. This analysis involved the influence of the insulation thickness and was restricted to Detroit, Michigan. Figure 15 shows the average predicted moisture content after one week of drying in the outer and inner halves of 2×4 and 2×6 CFI beds. Moisture content at the end of one week's drying time is consistently and substantially lower in the inner halves of the insulation beds than in their outer halves, regardless of the full thickness of the insulation. The analysis indicated that moisture is dissipated more rapidly from 2×4 walls than from 2×6 walls. During warm weather, predicted moisture content in the outer

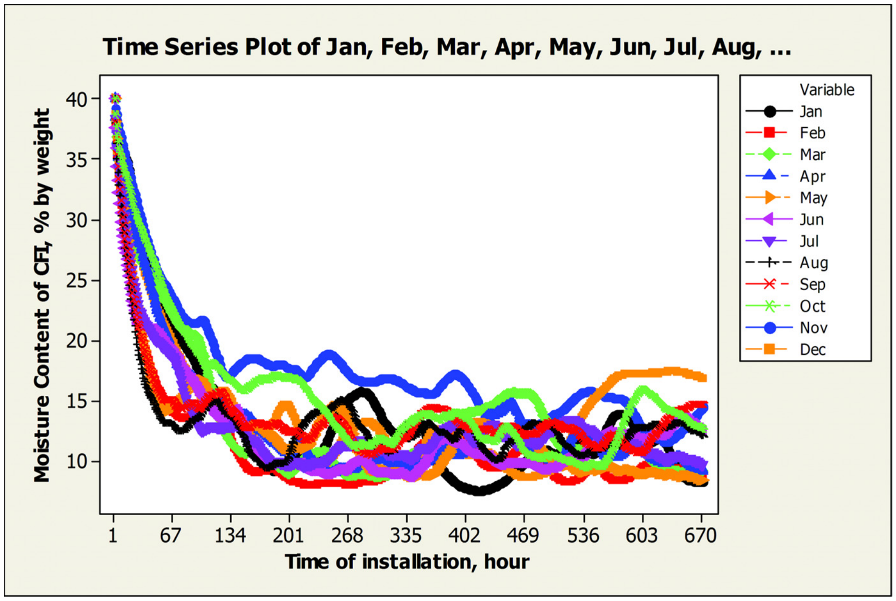

Figure 13 *The moisture content of CFI (average through the exterior facing half thickness) as a function of time (in hours) since its installation. The installation occurred on the first of the month in San Antonio, Texas.*

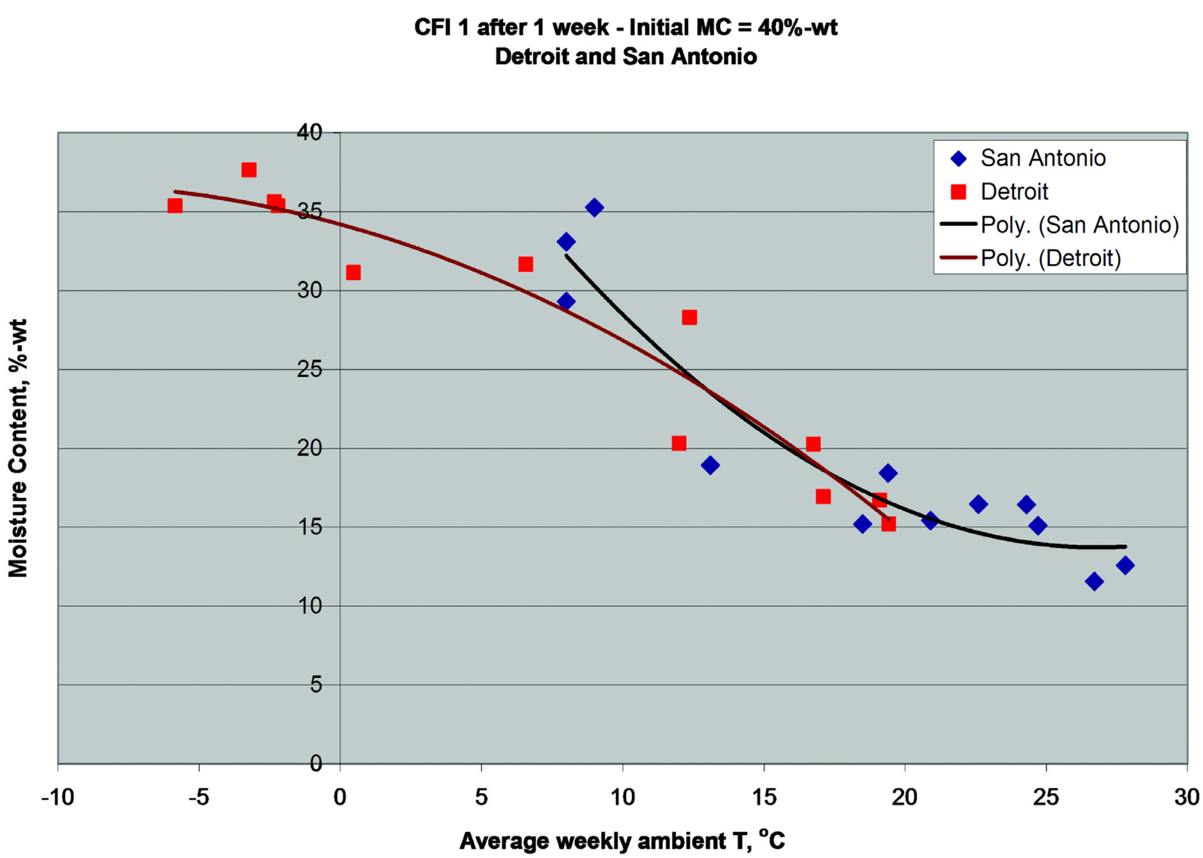

Figure 14 *The average moisture content of the exterior half of the 2×4 layer as a function of average weekly ambient temperature (locations: Detroit, Michigan, and San Antonio, Texas).*

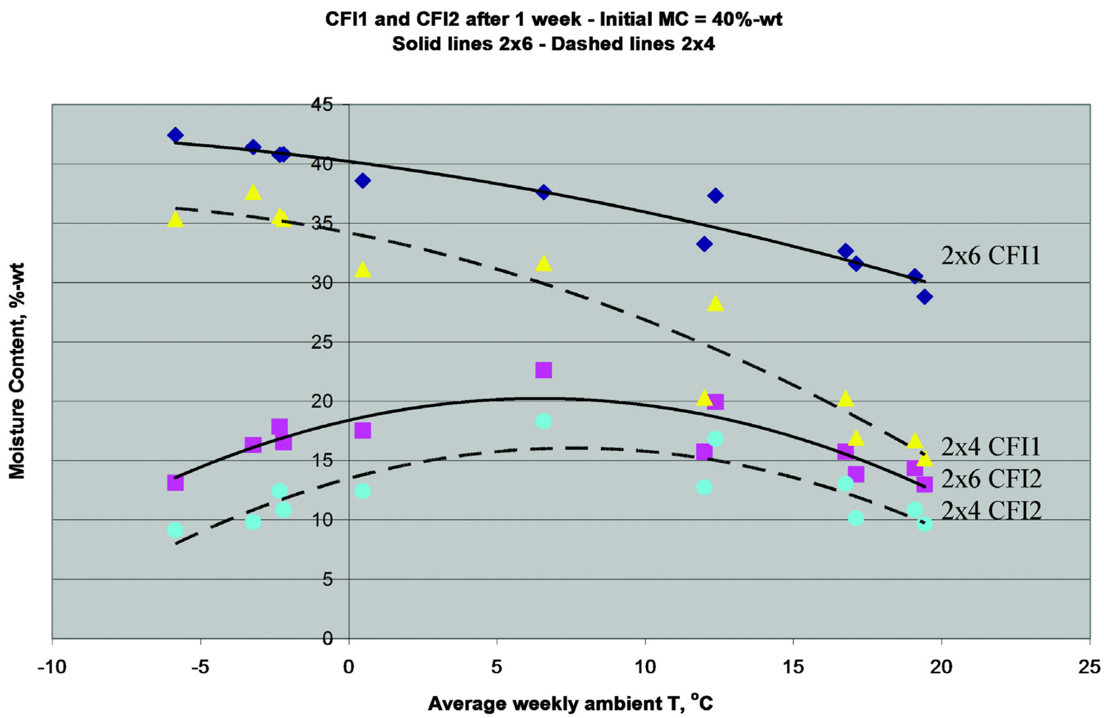

Figure 15 The average moisture content of the exterior and interior half of the CFI after one week of drying as a function of average ambient temperature (3.5 and 5.5 in. insulation thicknesses). Location: Detroit, Michigan. Initial moisture content of the cellulose insulation was 40% by weight.

half-layer in 2×4 walls fell below 20% within a week. In 2×6 walls regardless of time of year and in 2×4 walls in all except warm weather, predicted moisture content in the outer half-layer of insulation remains above 20% after one week of drying time.

DISCUSSION AND CONCLUSIONS

The drying characteristics of wall assemblies with spray-applied CFI are affected by the adjacent materials and by the exterior and interior climatic conditions. In assemblies with exterior sheathing with low water vapor permeability (i.e., OSB), the predominant drying direction is to the building interior. Under isothermal conditions, drying would occur through the path of least resistance and with low permeance exterior sheathing (i.e., OSB); the dissipation of moisture from spray-applied CFI would primarily occur toward the building interior. When there is a temperature gradient across the wall, moisture is driven in the direction of lower partial pressure of water vapor. Typically, in summertime the predominant direction of water vapor flow is toward the building interior and in the wintertime toward the building exterior.

Spray-applied CFI is installed in the field. The techniques and practices followed by the applicators were expected to govern the drying time of the installed insulation. The authors performed a field experiment and carried out simulations to investigate the drying time of walls insulated with spray-applied CFI. The experimental component of this work involved monitoring of drying response of north-facing wall assemblies in Georgia filled with CFI insulation applied by a professional installer in early January. Moisture content of the as-installed CFI insulation was substantially higher than recommended by the manufacturer, despite the professional installation. In this wall, high RH persisted on the inboard surface of the exterior sheathing for several weeks. Drying rate in this wall was also simulated using a commonly used hygrothermal model (Karagiozis 1998). Comparison of simulated and measured RH in this wall showed substantial agreement, provided that the effect of longwave (infrared) radiation was included in the simulation.

A series of simulations using the same model was then carried out to examine the drying rates of north-facing walls in a cold climate. The effect of time of year of installation of the spray-applied CFI was evaluated in this way. The simulations indicated that drying rate of the spray-applied CFI installed in cold climate/weather is slow, particularly in the outer layer of the insulation. A steep moisture gradient developed across the CFI, with high moisture content near the inboard surface of the exterior sheathing. Simulation results also indicated that moisture content in the CFI near the building interior declined below 25% within several days following its installation. This is due in part to moisture drying to the building interior and in part to moisture diffusing toward the building exterior where it could condense and accumulate.

When the outdoor temperature is sufficiently low, it may not be possible to dry the insulation, even in a few weeks time. The insulation layer will dry when the weather conditions are warm enough. When the drying period is significantly longer, the redistribution of built-in moisture is cause for concern. The moisture gradient that develops in the spray-applied CFI installed in cold weather can be expected to influence moisture readings taken from the interior with capacitive reactance type moisture meters (as recommended by the trade association). The meters most likely do not have sufficient depth of field to detect (from an interior location) elevated moisture conditions in insulation near the sheathing. It is important to know if the insulation is dry across its full thickness and not only on the surface or at mid-depth. This study indicates that the moisture content in the CFI should be checked at the location where elevated moisture conditions are most likely to occur, which, during cold weather, will be near the inboard surface of the exterior sheathing.

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