



The Implications of Drying Gypsum Plaster in Walls with Vapour Retardant Paint

Joel Schwartz P.Eng., FEC, BEP¹, Stephen Cork, BA²

1 JRS Engineering Ltd., Burnaby, Canada. joel@jrseengineering.com

2 JRS Engineering Ltd., Burnaby, Canada. scork@jrseengineering.com

ABSTRACT

In wood frame construction in the Lower Mainland of British Columbia, the most common wall assembly includes the use of a polyethylene sheet as the vapour barrier. Sequentially, this is installed after the batt insulation in the cavity, but before the installation of the interior gypsum wall board. This method of construction protects the wall cavity from high vapour drive during the drywall phase of construction by having the vapour barrier in place prior to the creation of the high vapour pressures. These vapour pressures are created by extremely high humidity due to the wet gypsum plaster and the heat applied to accelerate the drying process.

Alternate wall systems using a vapour barrier installed after the installation of drywall (vapour retardant paint) have also been utilized in wood frame wall assemblies the Lower Mainland of British Columbia and concerns have been raised about the ability of these wall assemblies to effectively manage these high vapour pressures, as the vapour barrier is not applied until after the drywall phase of construction is complete.

The authors involved in one such project became concerned when high moisture content was noted in wall assemblies during drywall finishing. Sensors were placed in and around the wall cavity to measure humidity, temperature and moisture content. This paper will present the initial results of this monitoring and will provide information learned in order to assist in understanding the patterns and risks associated with the wetting and drying of wall assemblies utilizing this method of construction.

1. INTRODUCTION

Polyethylene sheet is used in traditional residential wood-frame construction to control vapour flow in the assembly. Polyethylene sheet is installed between the studs and the gypsum board and is therefore in place prior to the installation of gypsum board and drywall compound. An alternative to polyethylene sheet is the use of vapour retardant paint (primer). The vapour retardant paint is a low permeability liquid applied product which is applied to the gypsum board after the drywall compound has been applied and sanding is complete. The vapour retardant paint serves as a primer for the finish paint and as the vapour diffusion control layer in the wall assembly.

This paper examines the effect of using vapour retardant paint to control vapour flow in the new development construction of three-storey townhomes located in Surrey, British Columbia. The owners of the development in this study had chosen vapour retardant paint in place of polyethylene sheet. These new developments consist of multiple three-storey townhomes built in clusters of four to eight units. These townhomes were built under Part 3 (and therefore Part 5) of the 2006 British Columbia Building Code). The specific unit that was used for this study is part of a six-townhome cluster. There are two townhomes to the west of the unit and three townhomes to the east. The cluster involved in the study was constructed on a sloped lot with two exposed floors at the south elevation and three exposed floors with garage at the first floor. There are 2' overhangs at the roof levels and according to the Best Practice Guide the building is considered "Medium" exposure. The buildings are clad in vinyl siding with ½" pressure treated strapping installed between the Tyvek Housewrap moisture barrier to form a drainage cavity. In this assembly the Tyvek is intended to serve as the moisture barrier only. The drywall, by using a system of gaskets and sealants, is detailed as the air

barrier in the assembly and vapour retardant paint is used to provide control against vapour diffusion. Vapour diffusion ports are used in the wall cavities.

As part of a quality assurance program, moisture content readings were taken in the OBS sheathing and framing during installation of drywall in the unit. It was discovered that at elevated moisture content (MC) readings were noted in the oriented strand board (OSB) and framing adjacent to areas where drywall mud was being installed. These areas had previously been monitored and found to be lower despite the fact that electric heat had been provided in an effort to lower the MC prior to installation of insulation and gypsum board. This paper will study the implications of adding a significant interior moisture source. As well as, the resultant vapour drive created by the use of propane heaters and the moisture contained in the drywall mud prior to the installation of the vapour barrier in the assembly. This paper will assess the associated risks of this approach by installing the vapour barrier immediately after the introduction of the high moisture load sealing the moisture in the walls.

2. METHOD

SMT Research supplied data acquisition units called WiDAQs, which reads and records sensor readings. They were used to measure the conditions in and around the wall assemblies. The WiDAQs were installed at two locations on the third floor of the townhouse unit. One set of sensors were installed at the south elevation and one set of sensors was installed at the north elevation. At each location the items monitored included relative humidity in the room, wall cavity, and outside; temperature of the room, wall cavity, into sheathing (OSB), drywall, and outside and moisture probes reading the sheathing (OSB) and drywall.

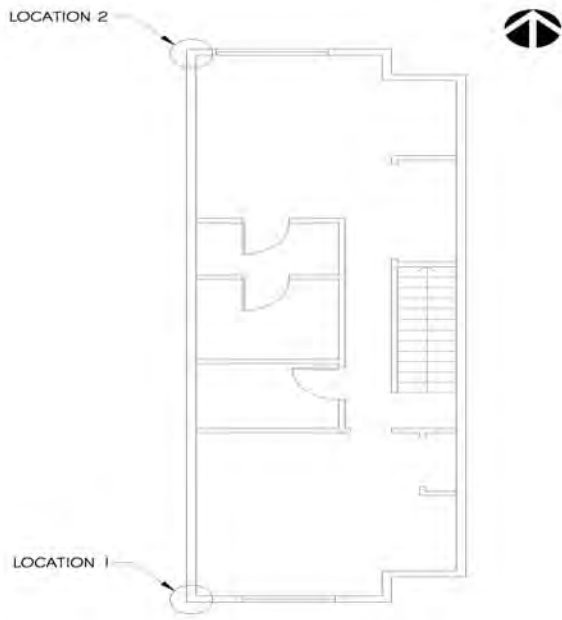


Figure 1. Floor plan location of sensors.

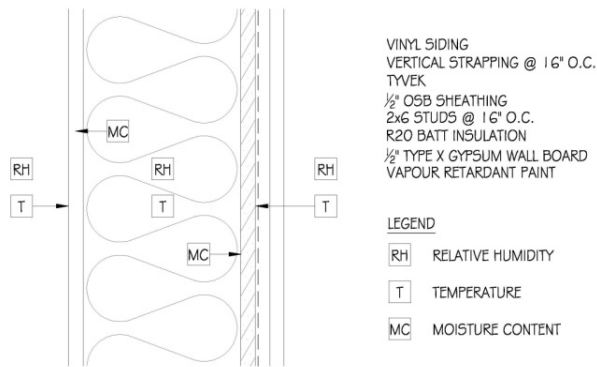


Figure 2. Location of sensors in the wall assembly.

Sensors types interfaced to the WiDAQ for this study included temperature, moisture and relative humidity. The SMT Point Moisture Measurement (PMM) probe was used to collect moisture and temperature data at various locations in the wall system. Humeral HTM2500 and HTM1735 RH sensors were used to profile the interior, wall cavity and exterior relative humidity values.

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3. CONSTRUCTION SEQUENCING AND DATA COLLECTION

Prior to installation of the WiDAQs, moisture content readings were taken with a Delmhorst BD-10 moisture meter. The MC was found to be less than 19%.

The WiDAQ sensors were installed on February 12, 2009; however, they were not fastened to the gypsum in the cavity until March 9, 2009. At this time, the mudding at this area had been completed.

When the moisture content readings were measured again, but this time with the WiDAQs, the probes were pushed farther to the exterior and the MC measured significantly higher. This may have been attributed to the use of electric heaters used to dry the building prior to the installation of the batt insulation. This may have created a vapour drive to the exterior and / or the unreliability of resistance based moisture meters at higher percentages of MC. At the time of these readings the exterior moisture barrier had been installed, however, the cladding had not.

According to the contractor, the installation of the insulation in the unit was completed on February 22, 2009, and the installation of the gypsum board occurred between February 24 and March 2, 2009. The application of the propane heat and drywall mud occurred from March 2 to March 18, 2009. The installation of the vapour retardant primer was installed immediately after the final coat of mud was dry and sanded.



Figure 3. Installation of sensors on gypsum

4. DATA COLLECTED

The primary intent of the study was to discover if there was a significant amount of moisture deposited into the cavity during the mudding stage and if so, if the wall assembly could effectively manage these moisture loads over time.

Data was collected from February 12, 2009, until May 3, 2009, at which time the sensors were removed prior to occupancy.

A significant amount of data was available and options for sorting and organizing the data was exhaustive. For purposes of this study, the following data fields were selected for their relevance. The data was averaged at 12 or 24 hour intervals.

It should be noted that only two locations were selected and some of the data collected at these locations was incomplete. Where data was incomplete the values were averaged.

The time frame of the occurrence of the various activities was provided by the contractor and some of the data collected indicates the time frame provided may not be accurate.

4.1 Interior Temperature and RH

As part of the mudding process moisture in the form of drywall mud and propane heat is added to the room.

We would expect that the temperature and RH would remain relatively constant until the high moisture load of the mudding process.

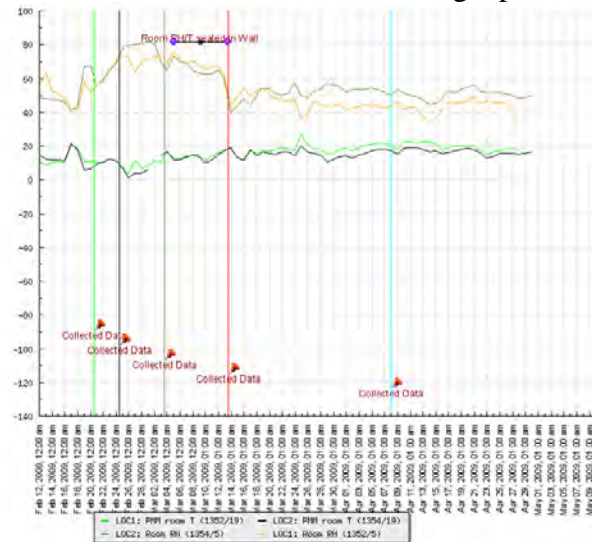


Figure 4. Room temperature and RH.

The temperature during the insulation process varied from 6 degrees to 21 degrees. The average temperature at Location 1 (South) and at Location 2 (North) was 12 degrees. The RH varied from 40% to 67%. The average RH at the south elevation was 53% and 54% at the north elevation.

During the boarding stage the temperature varied between 1 degree and 11 degrees. The average temperature at the south elevation was 8 degrees and 6 degrees at the north elevation. The RH varied from 64% to 82%. The average RH at the south elevation was 78% and 70% at the north elevation.

During the mudding stage the temperature varied between 11 degrees and 19 degrees. The average temperature at the south and north elevation was 14 degrees. The RH varied from 40% to 81%. The average RH at

the south elevation was 61% and 64% at the north elevation.

After the mudding stage and until the end of data collection, the temperature varied from 11 to 27 degrees. The average temperature at the south elevation was 19 degrees and at the north elevation was 16 degrees. The RH varied from 32% to 57%. The average RH at the south elevation was 52% and 44% at the north elevation.

The data collected, particularly the temperature suggests that the time frame provided by the contractor may not be accurate. Specifically we note that there were four periods where there were noticeable spikes in temperature, February 16-18, March 3-4, March 13-15 and March 22-25.

4.2 Room temperature and RH

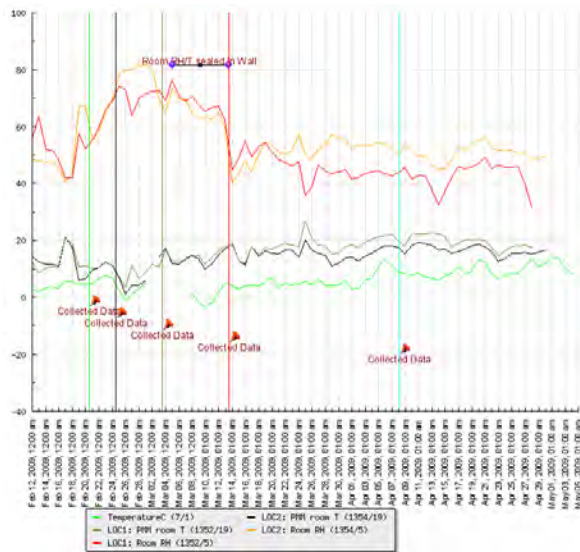


Figure 5. Room temperature and RH.

The temperature in Location 1 (south) varied from 8 degrees (March 18) to 25 degrees on March 25th. At Location 2 (north) the temperatures were a minimum of 2 degrees on February 26th and peaked on May 2 at 18 degrees. The temperature difference between the south and north elevations varied however was generally warmer at the south elevation

with a peak temperature difference of 7 degrees on March 25th.

The RH at Location 1 varied from 35% on March 25 and 77% on March 4. At Location 2 the RH varied from 53% on February 12 and 86% on March 5. The average RH for data available at location 1 was 55% and at Location 2 was 70%.

4.3 Vapour Pressure and Vapour Flow

The vapour pressures were calculated in the room, wall cavity and exterior at both locations to understand the flow of vapour throughout the study.

At Location 1, 30% of the days showed vapour pressures in the cavity being greater than vapour pressures inside and outside resulting in vapour flow to both the exterior and interior. In 55% of the days, drying was to outward only. In 15% of the instances data was lost and vapour flow calculations were not able to be performed. The pre-mudding, and mudding stages showed that approximately 85% of the time vapour flow was to the exterior only, and 15% of the time vapour flow was to both the exterior and interior. After the mudding stage, and once the vapour retardant paint was added the vapour flow was outward approximately 30% of the time and both ways 70% of the time.

At Location 2, 95% of the days showed vapour pressures in the cavity being greater than vapour pressures inside and outside resulting in vapour flow to both the exterior and interior. In 2.5% of the days, drying was to outward only. In 2.5% of the instances data was lost and vapour flow calculations were not able to be performed. The pre-mudding stage showed that approximately 88% of the time vapour flow was to the exterior only, and 12% of the time vapour flow was to both the exterior and interior. During, and after the mudding stage all vapour flow was in both directions.

4.4 Moisture Content and Temperature of OSB Sheathing

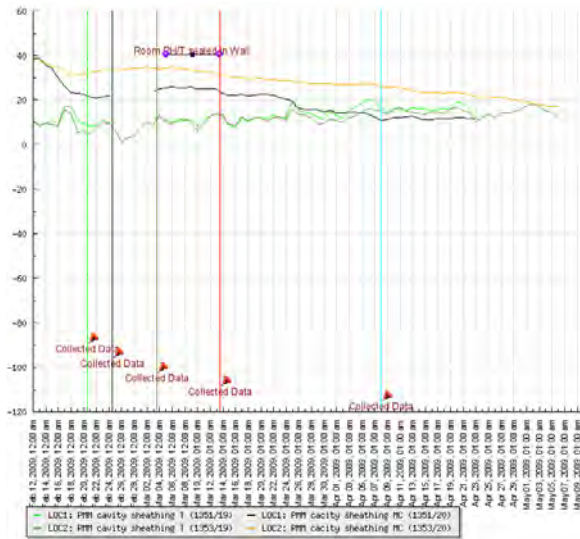


Figure 6. Moisture content and temperature of OSB sheathing.

The moisture content of the OSB sheathing was measured to be approximately 40% at the beginning of the monitoring at both locations. Prior to monitoring the MC at these locations the MC was measured with a Delmhorst handheld moisture meter and found to be less than 19%. The variation in MC measured may be possibly attributed to the varying depth of the placement of the pins or the inaccuracy of these types of resistance instruments at MC over 25%- 30%. The discrepancy between the two readings requires further review. For purposes of this study the MC measured by the WiDAQ sensors was utilized.

We found that in Location 1 (south) the MC did not dip below 19% until approximately March 26 and at Location 2 (north) not until May 2.

The temperatures in the wall cavities throughout the study at the south elevation varied from 5 degrees to 25 degrees. At the north elevation the temperatures ranged from 1 degree to 18 degrees.

At or below 19% MC wood is considered to be immune to fungal growth. In order germination of fungal growth to begin, MC of greater than 28% is required. Growth can be sustained where MC is greater than 19% under ideal conditions. The temperature range for optimal fungal growth is between 18 degrees and 35 degrees. This condition occurred only briefly in Location 2 (north) at the end of April.

At the end of the study the MC was below 19% and the temperature was well below 18 degrees.

The last day MC data was available for both locations were April 23. At this time the MC at the south elevation was 12% and at the north elevation the MC was 22%. At the end of the study, the MC at the north elevation was 18%.

The sheathing MC at the south elevation changed from an initial MC of 39% and finished at 12%, dropping 27%. At the north elevation the MC changed from an initial MC of 40% and dropped 22% to 18% at the end of the study.

It was found that the drying of the wall assembly was greater at the south elevation. Because of the occupancy of the building destructive testing was not conducted to confirm the condition of the OSB sheathing. Ideally, a sample of the OSB would have been available to weigh to compare against the data provided by the WiDAQ sensors and modeling of WUFI.

4.5 Moisture Content of Gypsum Board

The moisture content of the gypsum board varied from .24% to .37% at the south elevation and from .24% to .49% at the north elevation.

Spikes in the MC were sharp and returned quickly to more normal levels. We note at the

end of the study both locations were trending towards higher moisture content readings. We note that the change of MC of the gypsum correlated with times where the data was downloaded remotely.

At no time did the MC of the gypsum sheathing reach above .5%, the upper limit of where gypsum should be considered “dry” and there were only minimum times where the RH in the cavities was above 70%, however at these times the temperature was too low to support mould growth.

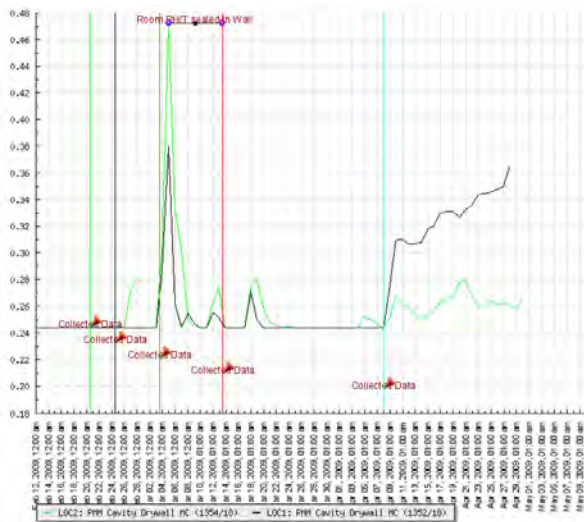


Figure 7. MC of gypsum sheathing.

4.6 WUFI Findings

In addition to the data provided by the WiDAQ sensors, a WUFI Pro 4.2, one-dimensional hygrothermal simulation software, was used to compare and contrast against the data measured.

Input parameters such as initial moisture content and in-situ conditions (interior and exterior relative humidity and temperature) were measured, recorded and directly inputted into the model. Components were selected from the program’s database that conformed to ASHRAE 1018 -RP (A Thermal and Moisture Transport Database for Common Building and Insulating Materials) as the wall

assembly components are not proprietary in nature but common building materials. The exterior rain wetting the surface of the wall was calculated by WUFI using the inputted rain load data from local weather stations. The solar radiation on the wall was neglected as the data was not readily available from local weather stations and the impact was not likely to be significant as the modeled orientation was the north elevation and the wall color is light. The simulation period was determined by the measure data period (February 2009 – April 2009). As this time period was during construction, different building components were inserted into the simulation over time.

The measured moisture content readings of both the exterior wood sheathing and interior gypsum were compared to the simulated moisture content readings to validate the experimental results and / or examine the limitations of the constructed model. The measured moisture content readings of the exterior wood sheathing correlated somewhat closely to the simulated moisture content readings. The measured initial and inputted moisture content was 25% and the measured final and calculated moisture contents were respectively 4% and 9%. The measured moisture content readings of the interior gypsum correlated poorly to the simulated moisture content readings. The measured initial and inputted moisture content was 0.3% and the measured final and calculated moisture contents were respectively 0.35% and 1.3%.

4.7 Discussion and Findings

As part of a quality assurance program the authors performed moisture readings of the wood framing and OSB sheathing of the subject project prior to installation of insulation and interior gypsum wall board. The Building Code requires the MC of the wood framing, prior to insulating be 19%. Concerns arose when insulating walls and subjecting the assembly to high moisture loads

prior to the installation of the interior vapour barrier (vapour retardant paint).

The risk of adding moisture into the cavity is that high humidity may result in mold growth on the gypsum board, wood framing, or OSB sheathing.

Our findings found that although the additional moisture load of the mudding process did affect the humidity and temperature in the cavity, the MC of the OSB sheathing continued on a drying trend to below the 19% threshold. The drying trends in the cavities were both inward and outward. The MC on the OSB sheathing did not however reach equilibrium which is typically between 6% and 12% in enclosed construction. The OSB at the south elevation dried to a lower level.

The high initial MC in the sheathing would be sufficient for fungal growth to start however, the temperature in the cavity was not warm enough to support growth.

A review of the minimum average temperatures in the cavity and maximum relative humidity shows that there is no potential for condensation within the cavity. Further modeling or data collection should be considered during warmer months to see if appropriate conditions for mould growth could occur.

The data collected for the MC of the gypsum sheathing showed that the opportunity for mould growth (greater than 70% RH and temperatures greater than 20 degrees) was non-existent.

5 Conclusions and Recommendations

The data collected shows throughout the duration of the study the opportunity for mold growth within the wall cavity using the vapour retardant paint method to control vapour flow is not supported and that despite the high

levels of moisture content originally measured, the MC of the sheathing fell below the level required to support mould growth.

Concerns over the validity of the data collected and the lack of specific data collected throughout durations of the study support the need for a greater sampling size over a longer duration, and destructive testing to confirm the validity of the data.

6 Acknowledgements

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7 References

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