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A STUDY OF THE DRYING POTENTIAL OF VARIOUS WOOD-FRAME WALL SYSTEMS USED IN ATLANTIC CANADA

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1. INTRODUCTION

The concern that a large number of housing units across Canada, and in particular, through Atlantic Canada are exposed to potential damage from wood rot due to moisture trapped within exterior walls caused a joint task force of Canada Mortgage and Housing Corporation and Canadian Home Builders Association representatives to address the "drying of walls" issue. Included in their mandate was a field research project in Atlantic Canada. The project, undertaken by Oboe Engineering Ltd. and ADI Limited. for the Project Implementation Division of CMHC, involved the erection of test huts in Halifax, Nova Scotia; Fredericton, New Brunswick; and St. John's, Newfoundland and the monitoring of the performance of eight different types of wall construction for a one year period.

To assess the drying rates, the wall panels used in this experiment were intentionally designed with saturated lumber. **As such, high values of equilibrium moisture content recorded and presented in this report, must be considered in relation to the design of the experiment, and not a function of the products or materials incorporated in any particular wall assembly.**

The experimental procedure involved monitoring temperature, relative humidity, pressure, structural moisture content, wind speed and direction, and presence of condensation in each wall panel, in each city, each hour, for one year. This report presents an overview of the results, global trends in the drying of walls, and the sensitivity of wall permeance, geographic location, compass heading and presence or absence of furring strips to wall drying.

2. OBJECTIVES OF THE FIELD STUDY

The objectives of the study were:

* To investigate the effect of climatic differences on the drying rate of construction lumber

* To investigate the driving forces that effect wall drying rate

* To assess the differences in drying rates of furred and non-furred walls

3. TEST HUTS AND WALL PANELS

The test huts were one story buildings approximately 11 meters by 6 meters of floor area. The long dimension housed the test wall panels, and were oriented as north and south walls. All test huts were sided with slate blue vinyl siding. The materials used in the construction of each hut were identical from city to city.

The huts were electrically heated with baseboard heaters, and were humidified. The floor plan of a test hut is included as Figure 1.

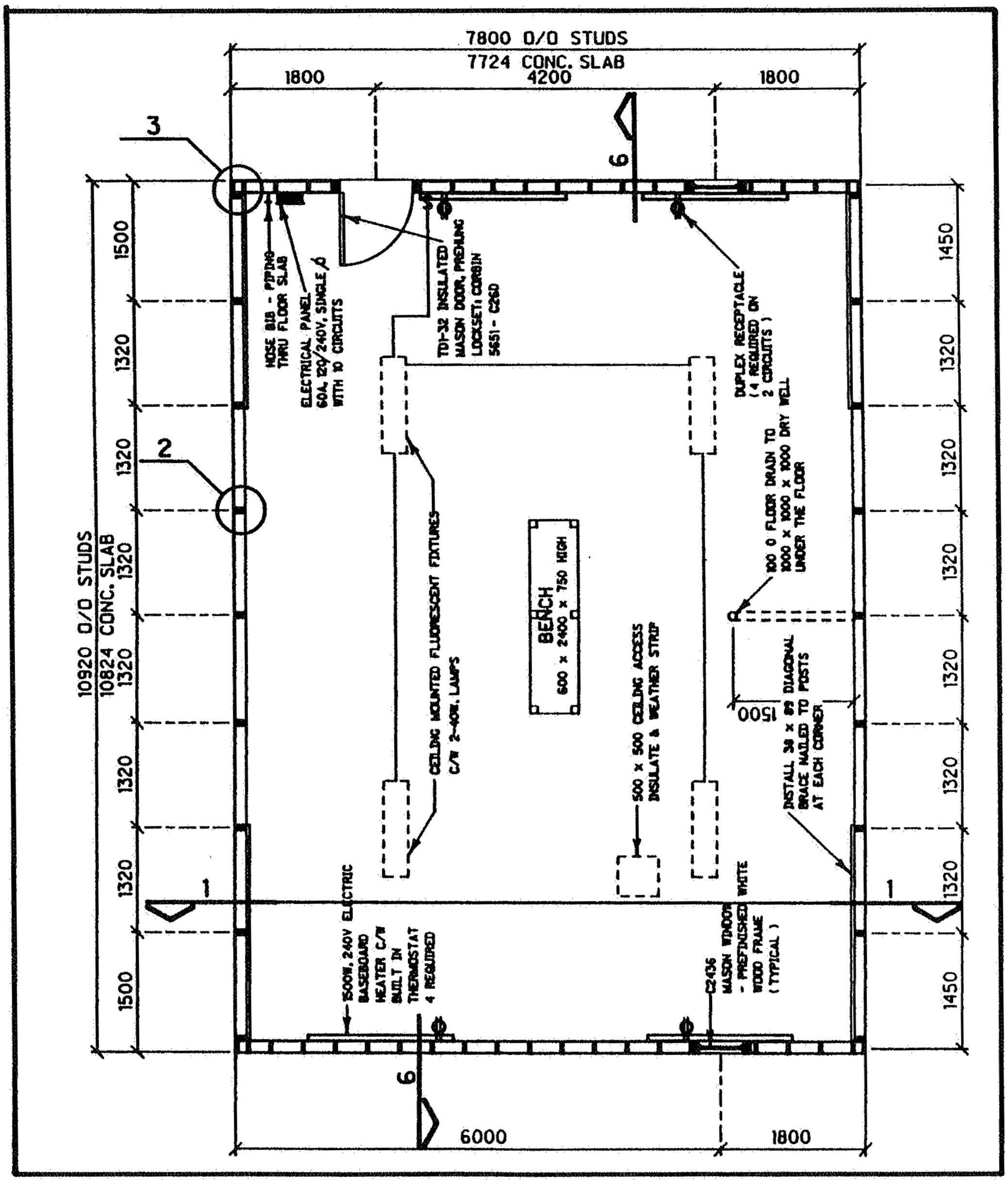

Figure 1: Floor Plan of Test Hut

3.1 Test Hut Construction

The huts were constructed with the cooperation of the University of New Brunswick, the Technical University of Nova Scotia, and the Newfoundland College of Trades and Technology, each of whom supplied on-campus land for the erection of the huts.

3.2 Test Wall Panels

The test wall panels were 2400 mm high by 1200 mm wide, and framed on 400 mm centres. The eight test wall panel set, included as Figures 2 and 3, consisted of a furred and non-furred waferboard sheathed pair, a furred and non-furred rigid fiberglass sheathed pair, a furred and non-furred extruded polystyrene sheathed pair, a cellulose insulated panel, and an expanded polystyrene insulated panel. Throughout this report, the wall panels will be referred to by their respective panel numbers, for simplicity. Note that panel 2 is a furred version of panel 1, that panel 4 is furred version of panel 3, and that panel 6 is a furred version of panel 5. Each panel was instrumented as depicted in Panel 6, Figure 3. Each of the eight panels were installed in the south wall of each test hut, and repeated on the north wall.

The panels were to be constructed using lumber with a moisture content of 26-30%, in comparison to Canadian Building Code requirements of less than 19%. It is of interest to note that the lumber supplied for the construction of the wall panels was from local building supply dealers, from the stockyard. No conditioning was required. All of the lumber was above 26% equilibrium moisture content. These high values are consistent with the results of a framing moisture survey undertaken by the Project Implementation Division of CMHC for the Task Force. In addition, the cellulose panel (Panel 7) was installed as a wet spray, and consequently an additional amount of water was added into that wall cavity.

To minimize the effects of drying towards the edges of each wall, the vapour barrier was wrapped around the edges of each test panel, and sealed against the studs.

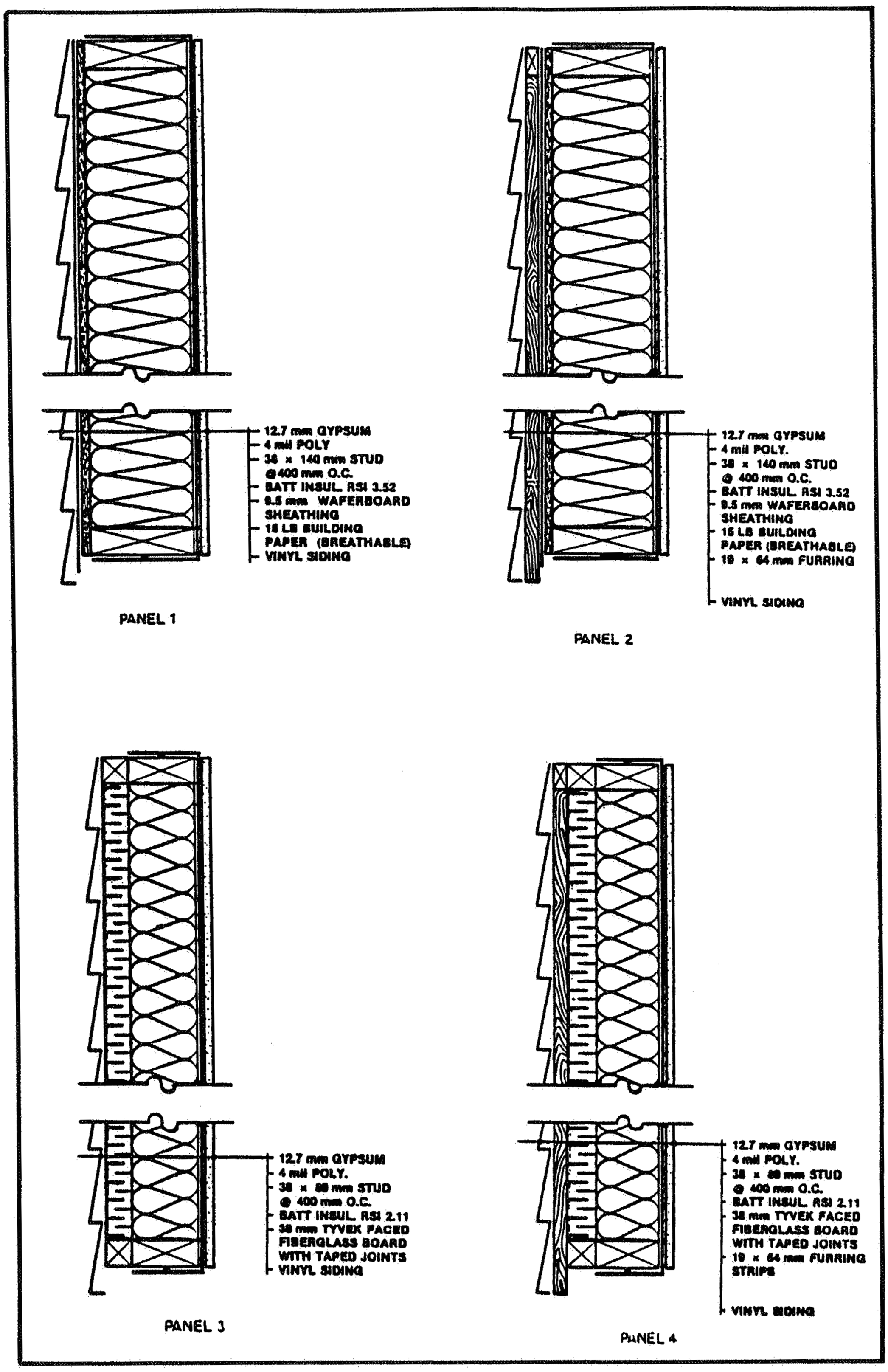

Figure 2: Test Panels 1 to 4

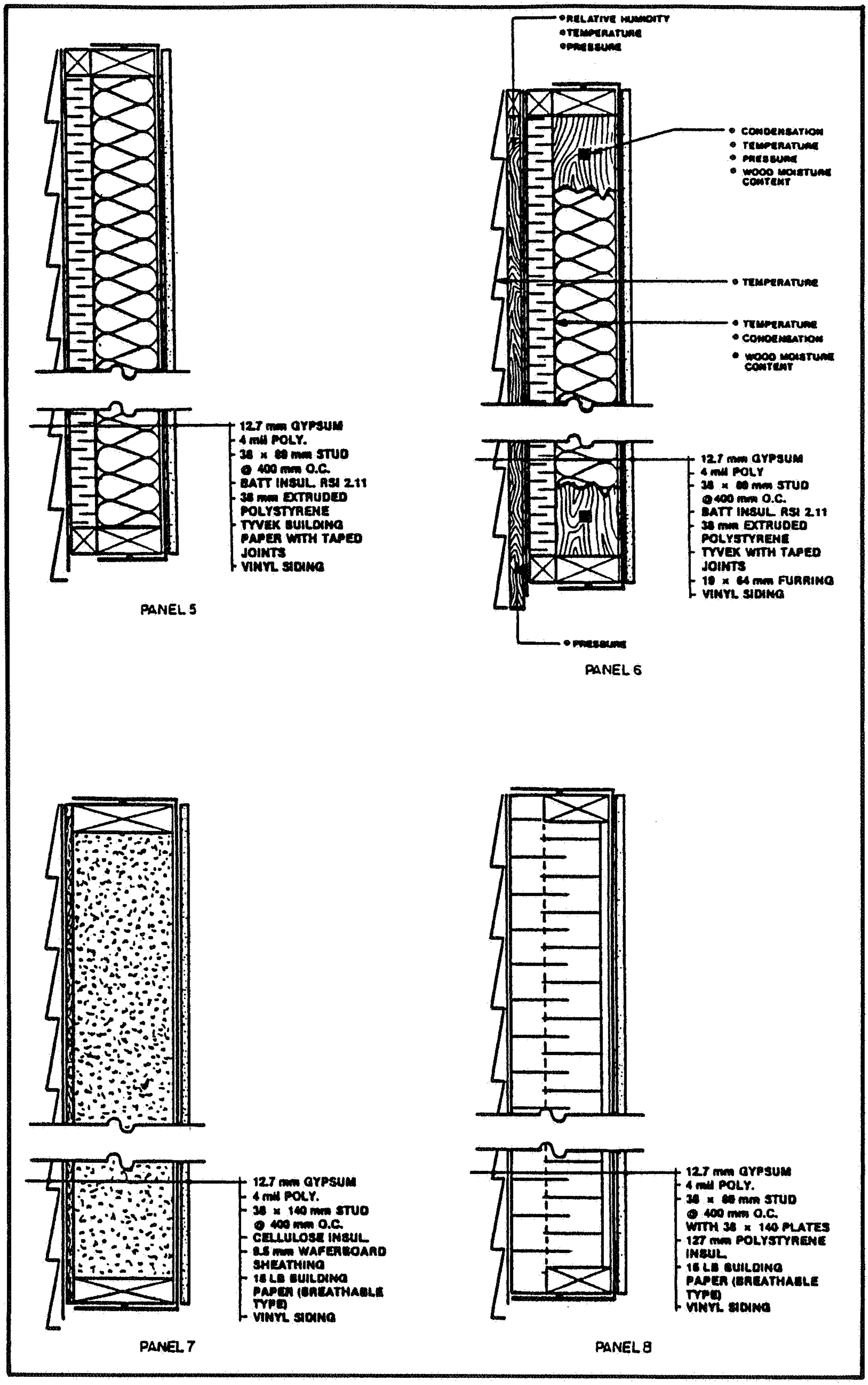

Figure 3: Test Panels 5 to 8

3.3 Test Panel Moisture Transfer and Thermal Properties

The thermal and moisture transfer properties through the insulation of the wall panels are summarized in Figure 4. The thermal resistance is tabulated for the total wall assembly, however, the moisture transfer values include only the sheathing and sheathing paper combinations. It is considered that in the case of this experiment, the moisture flow from the wall cavity will be towards the exterior of the wall and not the interior. This is due in part to the low permeance of the polyethelene vapour barrier, 4 ng/Pa-s-m^2, and its relatively tight installation. As such, each wall's drying capability through the sheathing system is of interest.

Panel	Thermal Resistance (RSI)	Sheathing & Paper Permeance (ng/Pa s m^2)
1. Non-furred, 38x140 studs, batt insulation, wafer board sheathing, 15 lb. building paper, siding.	4.09	43
2. Same as Panel 1, with furring.	4.26	43
3. Non-furred, 38x89 studs, batt insulation, rigid fiberglass sheathing w/Tyvek, siding.	3.77	1723
4. Same as Panel 3, with furring.	3.94	1723
5. Non-furred, 38x89 studs, batt insulation, extruded polystyrene sheathing, Tyvek paper, siding.	3.92	35
6. Same as 5, with furring.	4.09	35
7. Non-furred, 38x140 stud, cellulese insulation, wafer board sheathing, 15 lb. building paper, siding.	3.88	43
8. Non-furred, 28x140 stud expanded polystrene insulation, 15 lb building paper, siding.	3.74	47

Figure 4: Test Wall Thermal and Moisture Transfer Properties

4. OVERVIEW OF THE MONITORING METHODOLOGY

Each panel was instrumented both 150 mm from the top, 150 mm from the bottom of a centre stud of each panel, and at mid height, with the following sensors:

a. Thermocouple
b. Pressure tap
c. Condensation gauge
d. Wood moisture pins

Wood moisture pins were installed in the mid-height position, only in the panels that had wood based sheathings, 1, 2, 7. The instrumentation was placed in the centre 400 mm wide cavity of each wall panel, to minimize any edge effects where the test panels met the building structure.

In addition, the strapped cavities were instrumented for relative humidity (RH) and temperature. At one location on each the north and south walls, the inside surface temperature of the siding was monitored. Exterior relative humidity, temperature, wind speed and direction were measured by sensors located on a three meter high mast extending above the roof peak. Interior relative humidity and temperature were also measured. The interior relative humidity was controlled by the RH sensor connected to a humidifier.

4.1 Data Acquisition System

All sensors were connected to a Sciemetric Instruments Inc. Model 8082 Data Acquisition System which converted their analog signals to digital readings. An Apple IIe microcomputer read these digital values, converted them to the appropriate units (volts, °C, %RH, etc.), and saved them on a data desk. Each sensor was read at twenty minute intervals, and averaged values were saved to disk each hour.

5. RESULTS AND OBSERVATIONS

5.1 Weather Conditions

The ambient temperature, relative humidity, wind speed and direction were recorded three meters above the height of the roof of the test hut, or approximately 7.7 meters above the site grade. The measured values were compared against the averages recorded in the Canadian Climate Normals (Ref. 1 & 2).

On the average, the relative humidity profile was approximately 4%RH higher than the reported long term average values in Fredericton, and 8%RH higher in Halifax and St. John's. In all three locations, the measured temperatures were, on the average, 3° Celcius above the Climatic Normals. The average recorded wind velocity is approximately one-half the values of the Canadian Climatic Normals. However, the Canadian Normals are recorded at 20m mast height, on open terrain (at local airports). As such, the Climatic Normals would be higher than for an urban site.

5.2 Final Structural Moisture Content

Observations from Figure 5:

* In most instances the upper wall positions (2255 mm above grade) dried to a lower value than the lower wall positions (190 mm above finished grade), however the differences are slight.

* South facing walls dried to lower values that the north facing walls.

* The differences in south/north drying is more acute for walls of lower sheathing/sheathing paper permeance (panels 1, 2, 5, 6, permeance 35 - 43) than for walls with highly permeable sheathing combinations (panels 3, 4, permeance 1723).

* The presence or absence of furring strips had little effect on the final structural moisture content.

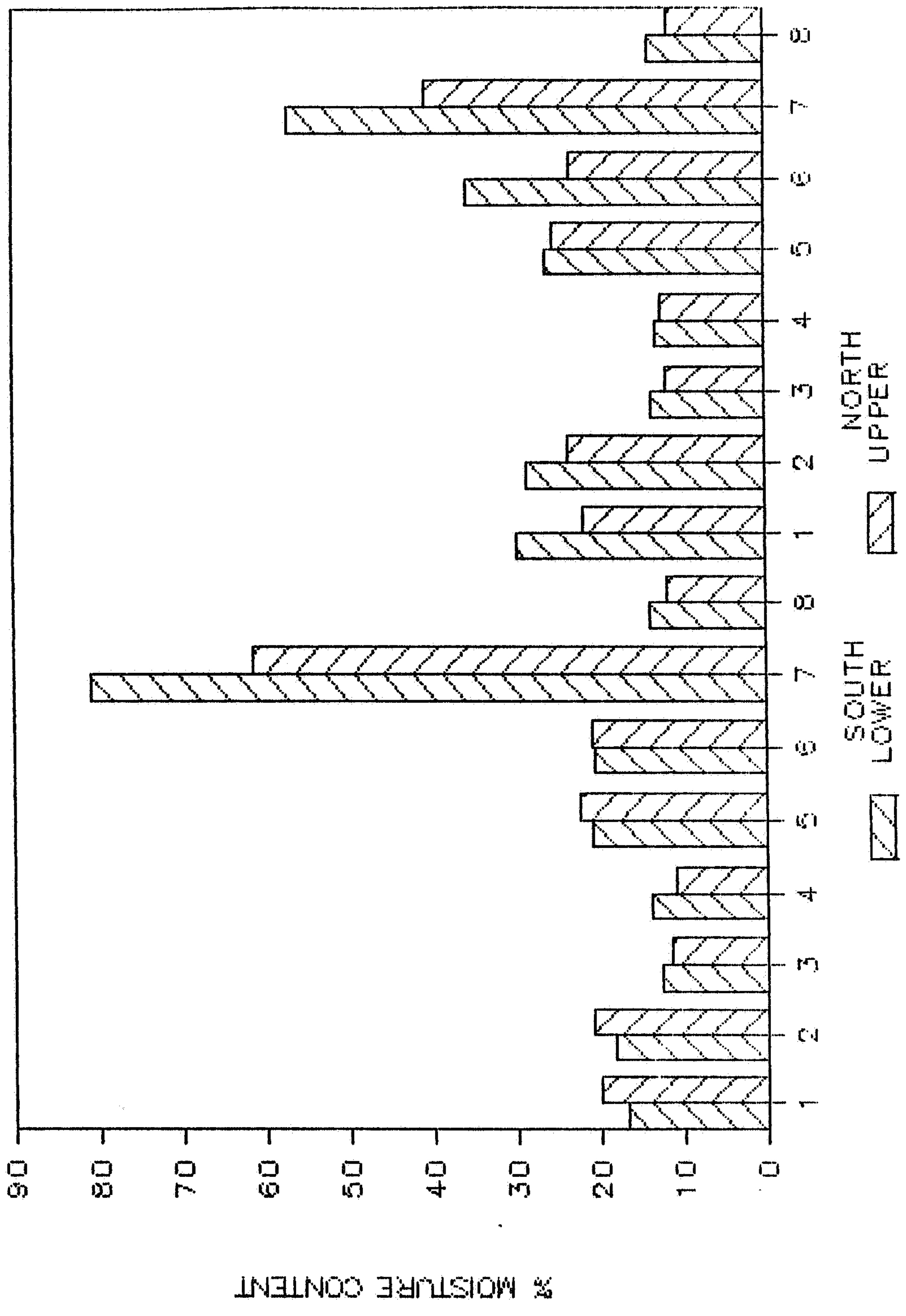

Figure 5: Average of Final Moisture Content Values

- Panel 8, with no sheathing other than felt building paper (permeance 800) performs similar to panels 3 and 4, which have high permeable sheathing combinations (permeance 1723).

5.3 Final Structural Moisture Content, Comparison to Building Code Requirement of Less than 19% MC

Observations from Figure 6:

- On the average, south panels 1, 2, 3, 4 and 8 have dried to the Building Code value.
- South panels 5 and 6 are very close to the Building Code value.
- On the average, north panels 3, 4 and 8 have dried to the Building Code value.
- Moisture conditions that promote decay are present in south panel 7, and north panels 1, 2 ,5, 6, and 7.

		Fredericton		**Halifax**		**St. John's**	
		Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
South	**1**	14	23	17	17	20	20
	2	16	22	19	23	20	18
	3	11	12	11	11	16	12
	4	15	13	12	10	15	10
	5	16	24	22	25	25	18
	6	26	28	18	20	18	15
	7	65	55	60	62	118	68
	8	14	10	13	12	15	14
North	**1**	28	20	31	25	31	21
	2	23	17	28	29	35	25
	3	11	11	15	13	15	12
	4	12	14	12	12	15	11
	5	33	30	17	23	29	23
	6	35	25	45	25	27	20
	7	45	32	51	45	76	45
	8	13	12	12	12	17	10

Figure 6 Table of Final Structural Moisture Content values, % MC

5.4 Rate of Drying

Observations from Figure 7:

- The south walls lost more water than the north walls. The actual total north wall moisture loss was 90% of the south wall moisture loss.
- In both the north and south walls, non-furred panel 1 dried faster than its furred counterpart, panel 2.
- The presence or absence of furring made very little difference to the drying rate of the high permeance panels, 3 and 4.
- In both the north and south walls, the furred panel 6 dried slightly faster that its non-furred counterpart, panel 5.
- The rate of drying increases as the permeance of the sheathing system increases.

Visual Inspection

5.5

The drywall, vapour barrier, and insulation was removed from the test wall panels in Fredericton on April 14, 1987 and the condition of the structural members noted.

In general, the south facing wall panels were found to be free of mold growth, with the exception of very slight black patches on panel 6. Minor swelling of the waferboard in panel 7 was noted. On the north face, all the waferboard sheathing, panels 1, 2, and 7 experienced swelling, and were visibly wet. In both panels 5 and 6, mold growth (black blotches) were evident on the studs.

The top row of siding was removed, to access the relative humidity sensors, and noted on the south side was total condensation coverage of the inside surface of the siding. The siding was removed at approximately 10:00 AM.

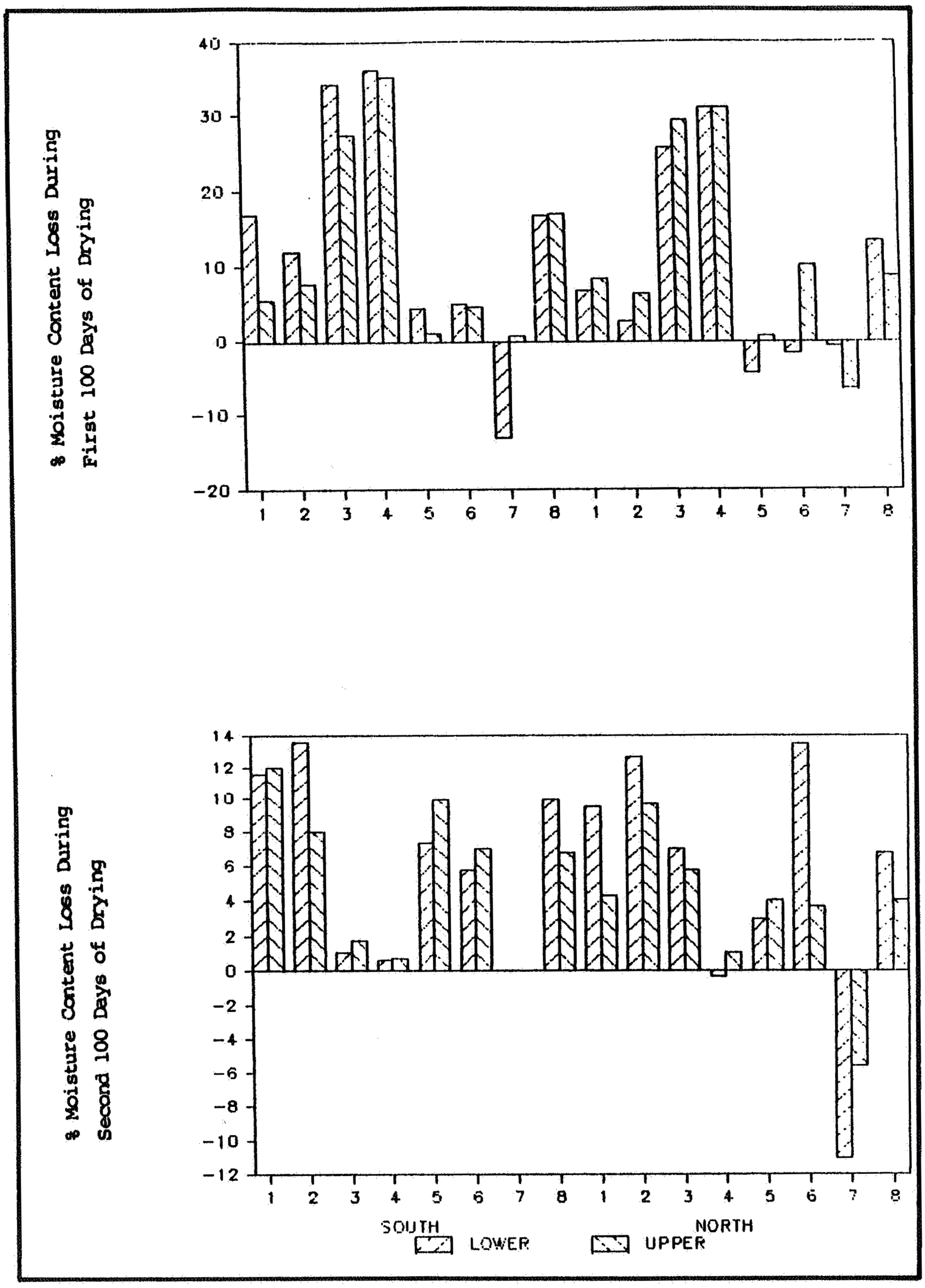

Figure 7: Average Rates of Moisture Loss is Test Studs, All Sites

6. DISCUSSION AND SUMMARY

6.1 Condensation

Conditions that allow condensation to form on the inside surface of the sheathings existed during December to March in all three locations. Conditions that allow condensation to form behind the siding were experienced during winter months, for a short period of time during the very early morning hours. These trends are not limited to the case of saturated walls, but to all wall assemblies, to varying amounts. Condensation can occur in limited instances on the cold side of structural members in a wall assembly in which the structural moisture content is below 19%. In dry assemblies, the low occurence of condensation would not usually present any problems. Indeed, in most of the wall assemblies in this project, the actual calculated occurences of condensation in wall panels of structural moisture content up to 26% was not great.

However, a trend that re-appeared with overwhelming consistancy was early morning condensation behind the siding. These conditions existed in Fredericton from October through April, in Halifax during February, and in St. John's in December and January. This free water was vapourized into the air in the strapped cavity during the daytime, as evidenced by comparing the rise in vapour pressure in the furred cavity, compared to the ambient, during the day. Although sensors were not present behind the siding of the non-furred panels, it is probable that the vapourization of free water was also taking place. However, in the absence of an air gap, the amount of free water vapourized could be less than the amount present, and thus wet conditions would remain.

6.2 Drying Mechanisms

The observations from this experiment suggest correlations of both air leakage and sheathing system permeance to the ability of a wall assembly to dry to the outside.

The north walls were not as consistent as the south walls in either drying rate or final moisture value. The south walls generally dried to acceptable values, while only the high permeance sheathing system panels did so on the north. The combination of low solar gain, and air leakage may reverse the drying trends to form wetting forces. The data from this study suggests this mechanism, but cannot be conclusive.

6.3 Furring Strips

The presence of furring strips had little effect on the structural drying of the test wall panels. However, the presence of the air gap behind the siding may have substantial benefits to the longevity of wood based sidings, and sheathings by providing a receiver for vapourizing water from the siding cavity. Further investigations in this regard are recommended, to validate or disprove this theory.

7. REFERENCES

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