Everything You Ever Wanted to Know About OSB... and Then Some

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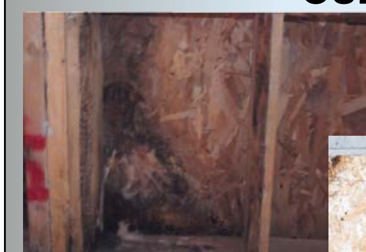
Toronto, Canada

Dynamic Wall House, 1984

So you want to design and build a building with OSB (Oriented Strand Board)…

- You want to make sure this building lasts a LONG time, avoiding moisture related problems
- Most of the time, it doesn't matter what type of OSB you use
- But sometimes it will matter and will make the difference between a wall working and failing

So how will you know when you need to know more about the OSB?

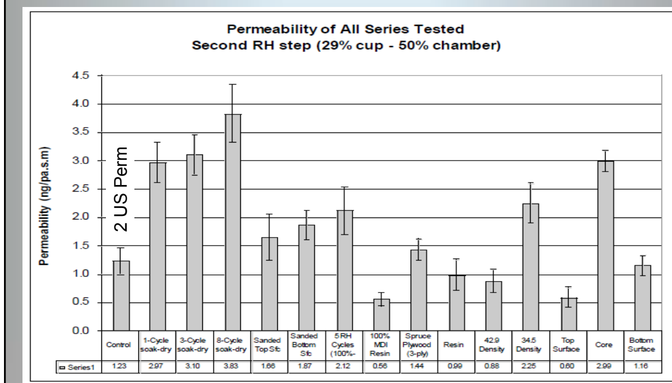


So how will you know when you need to know more about the OSB?

- If the wall assembly is new, different, in a new climate or of a "problematic type"
- Then model it (eg. WUFI hygrothermal simulation) and make sure you have the best material data possible
- Otherwise: garbage in = garbage out

Model the Wall Assembly

- But which OSB??



	Control	1-Cycle soak-dry	3-Cycle soak-dry	8-Cycle soak-dry	Sanded Top Sfc	Sanded Bottom Sfc	5 RH Cycles (100%-	100% MDI Resin	Spruce Plywood (3-ply)	Resin	42.9 Density	34.5 Density	Top Surface	Core	Bottom Surface
Series1	1.23	2.97	3.10	3.83	1.66	1.87	2.12	0.56	1.44	0.99	0.88	2.25	0.60	2.99	1.16

As a wise Building Scientist once said…

"Building materials do not fail. When building materials are assembled together and deleterious microclimates are created, it is the hand that has designed and assembled the materials that has failed!"

(J.Timusk)

Presentation Topics

- Background
- Research steps
- OSB Manufacturing and Variables
- Rationale for mill made panels
- Description of lab testing
- Significant findings

Background

- Historically, the "trial and error" approach to building worked well
  - What worked was repeated
  - What did not was discarded
- Designs were specific to climates
- Relatively few materials available

- After WWII
  - Rapid change
  - Increase in moisture related problems
- Timing coincided with advent of
  - Vapour barriers, sheet goods (plywood) increasing use of thermal insulation
- Increased air tightness and indoor rh
- Reduced drying potential in assemblies

- Globalization and economic prosperity soon made things worse:
  - New imported building designs
  - High efficiency furnaces and electric heating
  - Acceleration in development /availability of new building materials

Johnston Marklee Sale House

- Trial and error method no longer possible
  - Need quick and accurate prediction of enclosure performance
- **However**, predictions only as good as the **assumptions** / **material data**
- **OSB** is one such material

Oriented Strand Board (OSB)

- Structural wood composite material used for roof, floor and wall sheathing in wood frame construction
- Also used for rim joists, I-beam webs and SIPs

- OSB evolved from waferboard ("Aspenite" or "chip board"), which was first made by MacMillan Bloedel in Hudson Bay, Saskatchewan in 1963
- Al Owens in 1981 changed wafers into strands by modifying their aspect ratio so they could be "oriented" like the veneers in plywood

- Commonly produced in 4'x8' sheets
- Thickness from ¼" to over 2"
- North American production in 2012 was 17 billion square feet 3/8" basis worth **$7.62 Billion U.S.** (Natural Resources Canada)
- 2/3 of the production was in the U.S. and 1/3 in Canada

Why OSB?

- Less expensive than plywood
- Can engineer the properties
- Environmental
  - Made from fast growing underutilized species (eg. Poplar, Aspen, Southern Pine)
  - Can use insect or forest fire killed trees, smaller, crooked or otherwise less useable trees
  - Higher recovery factor/less waste than plywood

Rationale for Work

In order to predict / model hygrothermal performance of building enclosures and assemblies with OSB, need to know:

- Water Vapour **Permeance/Permeability**
- Water Vapour **Sorption**

Current State of the Art

- Little known of the effects of the OSB manufacturing parameters on permeance and sorption
- No investigation into effects of moisture exposure history (material data based on "virgin" osb)

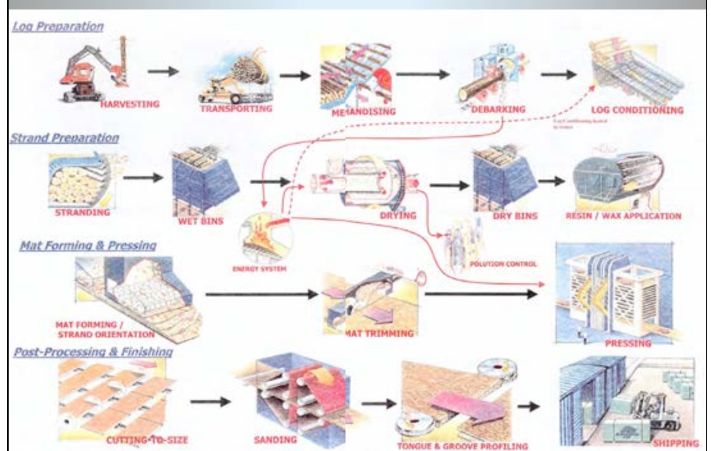
Research Steps

- One-day mill trial conducted to manufacture study panels at the Ainsworth 100 Mile House OSB mill (British Columbia, Canada)
- Test specimens prepared (component layers, RH cycled and water-soaked specimens)
- Water vapour permeance and sorption laboratory testing (three years)
- Test results analyzed, hygrothermal modeling (WUFI) investigations done using material data conclusions drawn

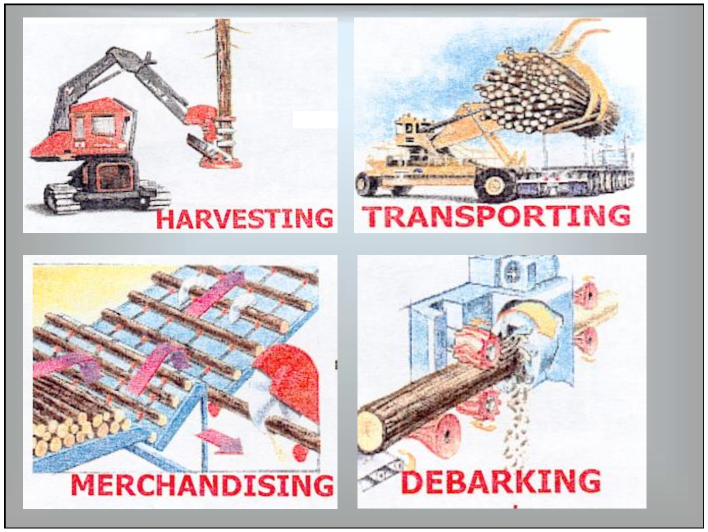
OSB Manufacturing Process and Variables

- Made from
  - Hardwoods: Aspen, Poplar, Birch
  - Softwoods: Southern Pine, Lodgepole Pine and others
- Strands bonded with a synthetic resin under heat and pressure
  - Phenol formaldehyde (PF), powder or liquid
  - Methylenediphenyl diisocyanate (MDI), liquid
  - Wax (emulsified or slack wax)

Process Overview

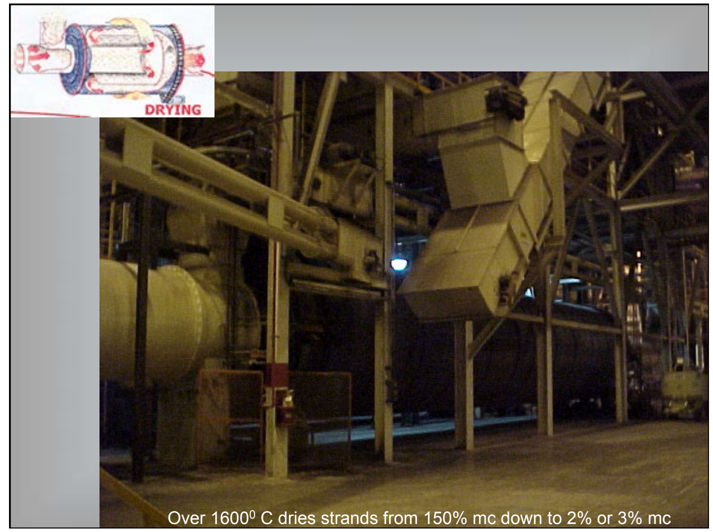


Ainsworth Lumber Company, 2000


HARVESTING
TRANSPORTING
MERCHANDISING
DEBARKING


LOG CONDITIONING


Strand Preparation
STRANDING
42 knives, 500 RPM, target thickness 0.025"



Over 1600^0 C dries strands from 150% mc down to 2% or 3% mc

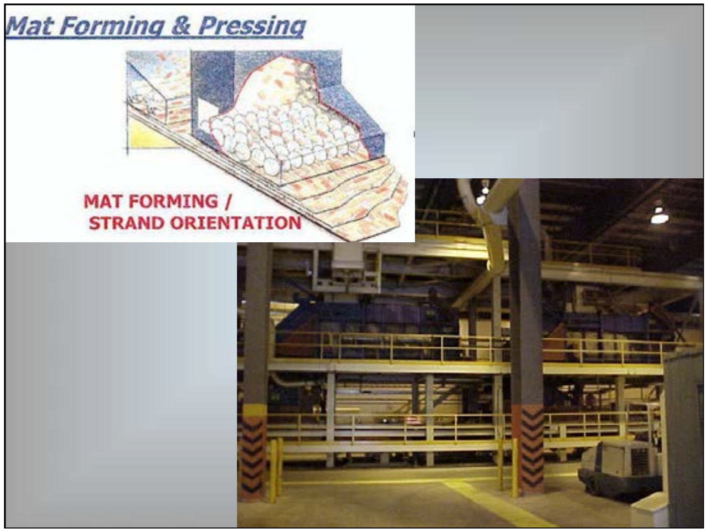
Drum Blender with 8 spinning disc atomizers, 10,000 to 15,000 RPM

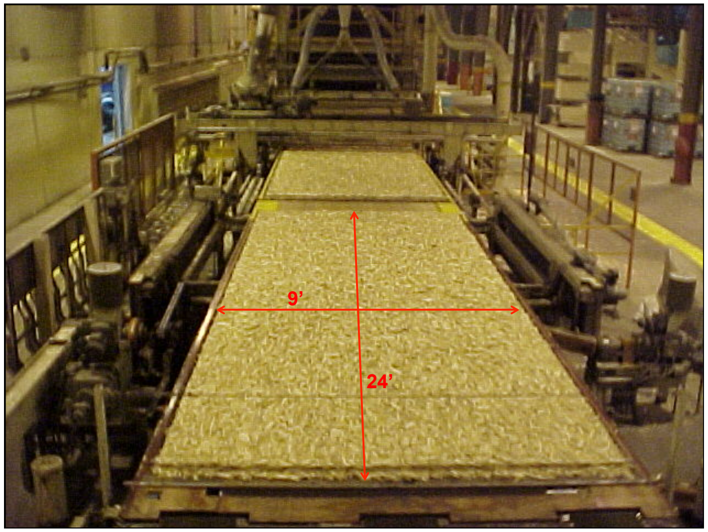
How Much Resin and Wax?

- **Surface Layers**:
  - 6% liquid phenol formaldehyde (PF) resin, (3% on solids basis)
  - 1.8% emulsified wax, liquid basis (0.9% on solids basis)
- **Core Layer**:
  - 2% methylenediphenyl diisocyanate (MDI) resin
  - 0.6% emulsified wax, liquid basis (0.3% on solids basis)

Forming

- OSB typically has 3 layers
  - – Top layer oriented in machine direction
  - – Core layer in X-machine direction
  - – Bottom layer oriented in machine direction
- Changing ratio and orientation changes parallel and perpendicular MOE and MOR





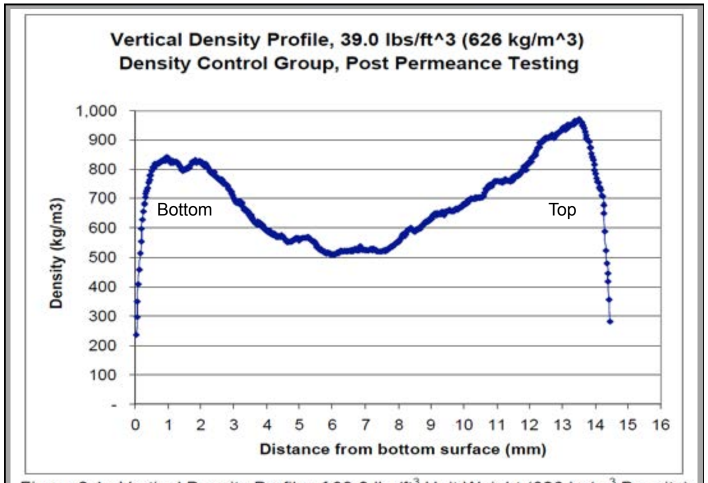


Figure 2.1: Vertical Density Profile of 39.0 lbs/ft^3 Unit Weight (626 kg/m^3 Density) Control Group OSB Panel, Post Permeance Testing by X-ray Densitometer.


SANDING


Ainsworth
ORIENTED STRAND BOARD
15/32 PRS
4 X 10


Ainsworth
OSB
100 MILE HOUSE B.C.
GRANDE PRAIRIE, ALBERTA
STRUCTURAL
RATED STURDI FLOOR
EXPORT

Rationale for Manufacturing Test-Panels in an OSB Mill

- Laboratory made panels do not accurately represent mill made panels (internal gas pressures, temperatures, heat transfer etc.)
- All experimental panels from this study represent what could be commercially available
- Author had access for one day to mill (one hour production valued at $10,000) where he had six years OSB research and development experience.

Mill Trial Variables

Variable	Range		
Density	Low	Medium*	High
(kg/m^3)	554	626	689
Resin (%)	Standard*	High	100% MDI**
Surface (PF)	3.0	4.25	4.25
Core (MDI)	2.0	4.0	4.25
Surface Treatments	Standard* Unsanded	Sanded top surface only	

Mill Constants

Wax addition %: surface 1.8%, core 0.6%
Target thickness: 0.430" (11 mm)
Pressing time: 153 seconds

Laboratory Testing

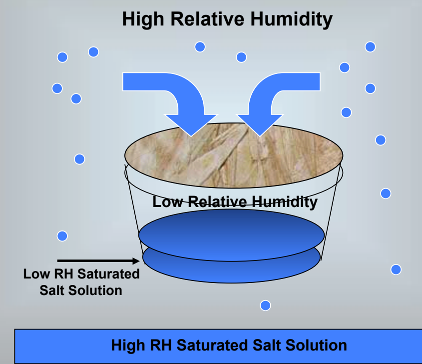
- Mill trial panels shipped from OSB mill in 100 Mile House, BC to Toronto
- Water vapour permeance and sorption testing conducted in the Building Science lab at the University of Toronto

Temperature and Relative Humidity Controlled Test Chamber

Permeance Test Assembly

Permeance Test Assembly

Modified ASTM
Cup Test



E-96 “Standard Test Methods for Water Vapour Transmission of Materials”

Permeance Testing Variables

Chamber Relative Humidity (%)	28	50	60	70	85	50
Cup Relative Humidity (%)	**2**	**29**	**53**	**64**	**75**	**100**
554 kg/m^3 (34.5 lbs/ft^3)	√	√	√	√	√	
626 kg/m^3 (39.0 lbs/ft^3)	√	√	√	√	√	
689 kg/m^3 (42.9 lbs/ft^3)	√	√	√	√	√	
Resin	√	√	√	√	√	
Top Surface	√	√	√	√	√	
Core	√	√	√	√	√	
Bottom Surface	√	√	√	√	√	
Sanded Top Sfc		√				
Sanded Bottom Sfc		√				
Control 626 kg/m^3 (39.0 lbs/ft^3)		√				
1-cycle soak		√				
3-cycle soak		√				
8-cycle soak		√				
RH Cycled		√				
RH cycle control		√				
Top sfc up		√				
Top sfc down		√				
100% MDI		√				
UHMW Plastic lid		√				
Spruce plywood		√				
Wet Cup						√
Inverted Wet Cup Top sfc wet						√
Inverted Wet Cup Top sfc Dry						√

Sorption Test Specimens

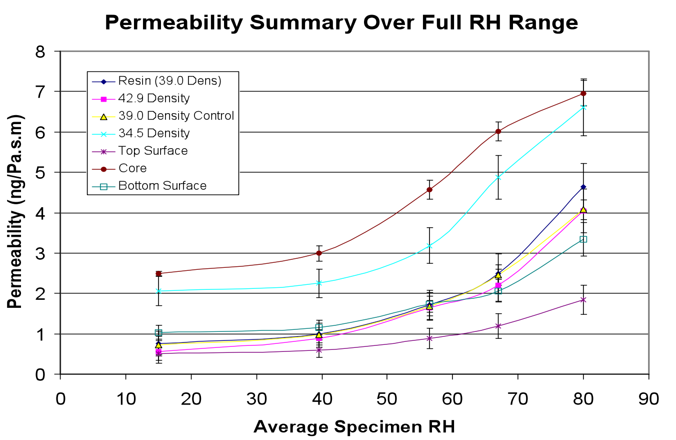
Sorption Testing Variables

Group / Variable	Full Thickness Discs # of Specimens	Slices # of Specimens	Planer Shaving # of Specimens
Resin (high resin)	3 (A, B, C)	10	
42.9 (688.6 kg/m³) Density	3 (A, B, C)	10	
39.0 (626.0 kg/m³) Density	3 (A, B, C)	10	
34.5 (553.8 kg/m³) Density	3 (A, B, C)	10	
39.0 (626.0 kg/m³) Density Oven Dried Before Test		10	
39.0 (626.0 kg/m³) Density Top Surface Layer		10	5
39.0 (626.0 kg/m³) Density Core Layer		10	5
39.0 (626.0 kg/m³) Density BottomSurface Layer		10	5
100% MDI Resin		10	
Red Cedar		5	
Pine		5	
Spruce Plywood		5	

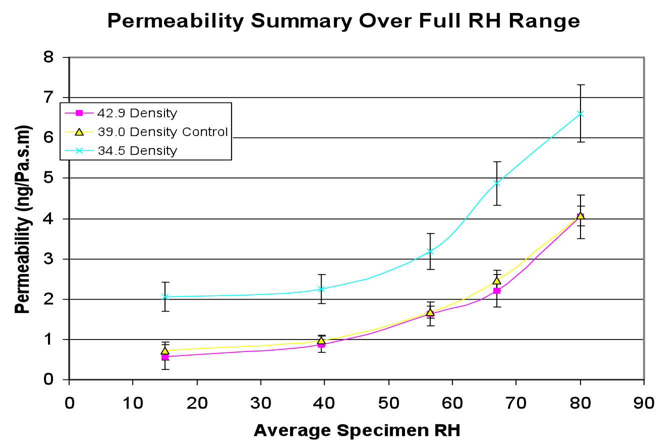
Significant Findings

- Permeability testing
- Sorption testing

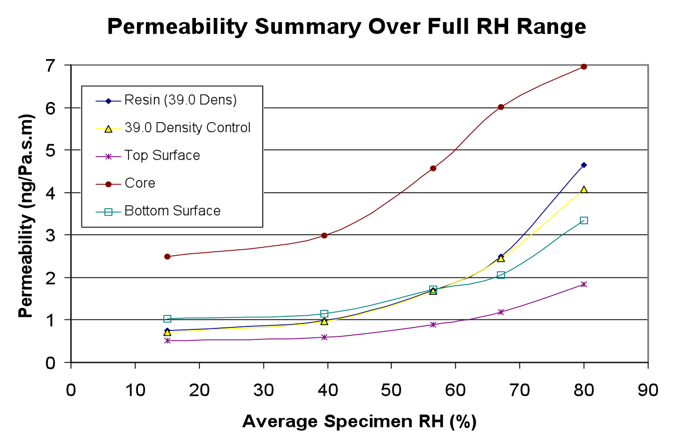
Series Tested over Full RH Range



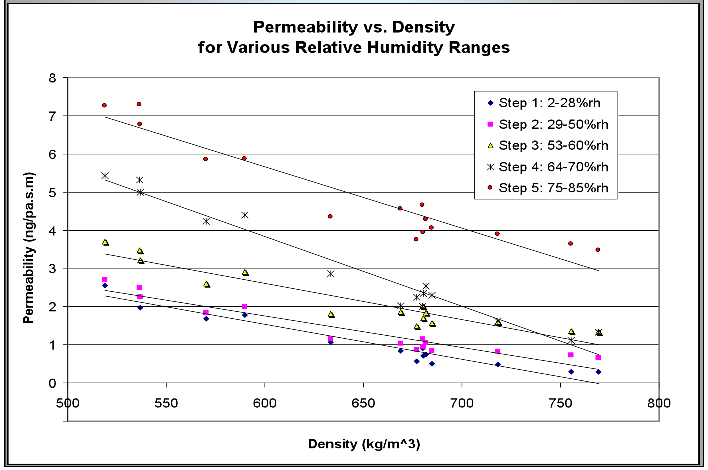
Density Comparison

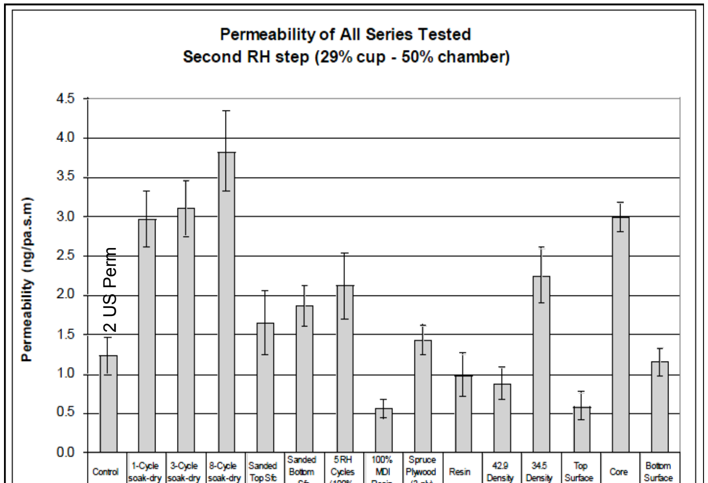


Component Layers and High Resin Series



Individual Specimens





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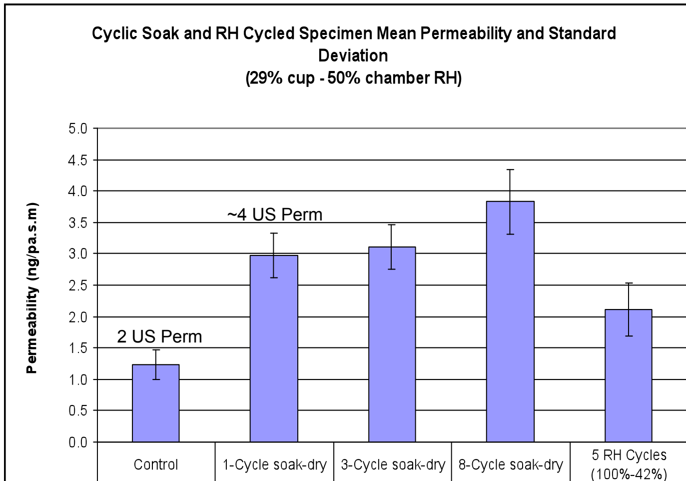
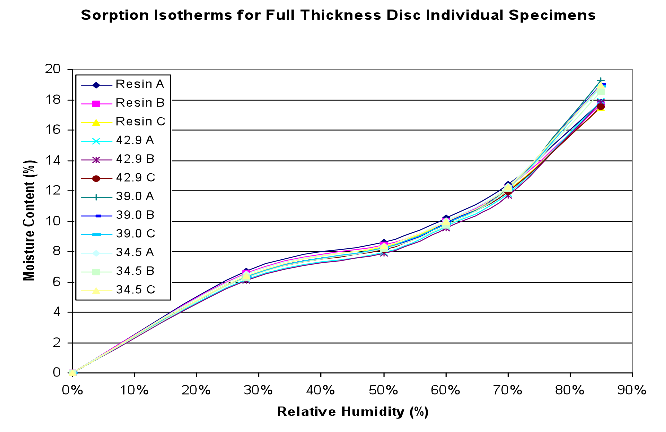
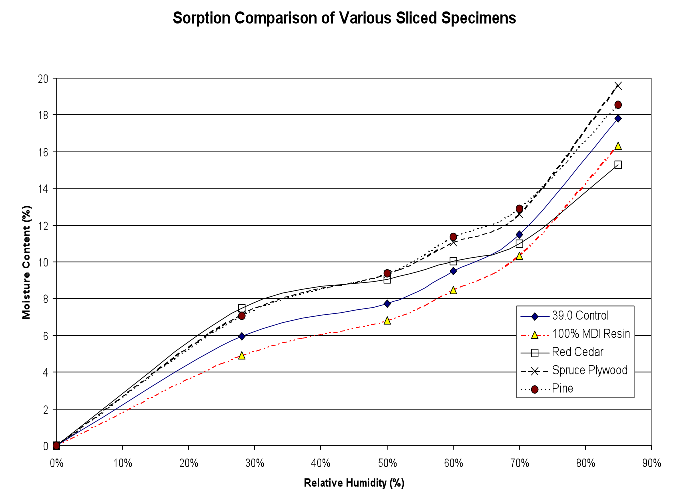


	Control	1-Cycle soak-dry	3-Cycle soak-dry	8-Cycle soak-dry	5 RH Cycles (100%-42%)
Series1	1.23	2.97	3.10	3.83	2.12

- The large increase in permeability with RH cycling perhaps most significant finding
  - Almost guaranteed that OSB will experience high RH or liquid water exposure during transport, storage or service life
  - With permeability increase of 1.7 to 3.1 times over unexposed control, basing performance predictions on virgin condition makes little sense.

Sorption Testing



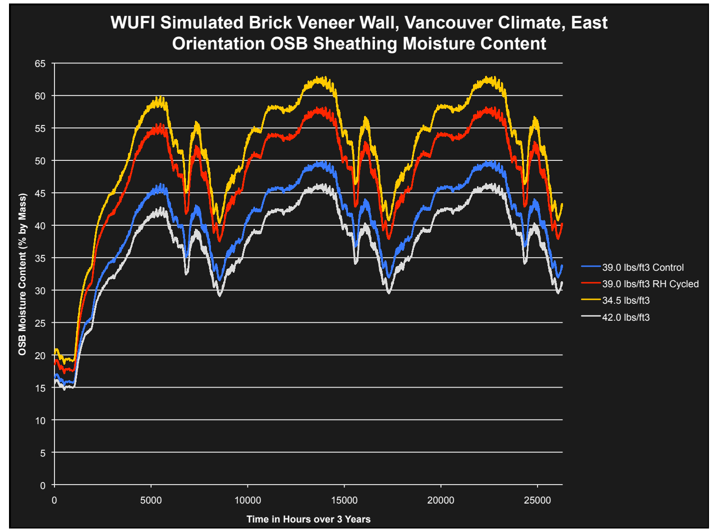


Hygrothermal Modeling

- Modeled with WUFI Pro 5.1, a one dimensional transient heat and mass transfer model
- New OSB materials were created based on the existing 650 kg/m^3 OSB in the WUFI material database using the material data generated experimentally (Sorption, permeance, density, porosity)

Hygrothermal Modeling

- 2x6 wood frame wall with brick veneer modeled in Vancouver climate, East orientation, 3 years
- Inside to out wall construction:
  - Gypsum board
  - 6 mil polyethylene
  - 5.5” (140mm) glass fibre batt insulation
  - 7/16” OSB (four types modeled)
  - ½” air space (3 ACH)
  - Brick veneer



THE END

Thank you!