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Creating forest sector solutions

Thermally Modified Wood Windows

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Introduction

- Wood windows have seen a dramatic decline in use in both North America and Europe
- Due to low natural durability and low dimensional stability
- Most end users prefer wooden windows but are not willing to do the necessary work for the maintenance hence the use of vinyl and aluminum clad windows
- New twist… increasing thermal performance requirements for all windows

How Wood Windows Fail

- Wood windows need maintenance every 2 to 3 years
- As long as the coating remains undamaged, the frame/sash remains intact
- The coating can receive mechanical, UV and water damage, with water damage having the greatest impact
- Once water enters the wood it is transported via capillary action (end grain) or by diffusion (side grain)

How Wood Windows Fail

- Water eventually detaches the coating from the wood which gives micro-organisms a chance to grow… rot develops
- Usually the bottom corner joints, along the bottom rail and the bottom end of the stiles

Preventing Wood Window Failure

- Goal is to reduce the water uptake and to reduce the effects of water in wood
- Wood modification technologies may provide the solution…
- …an added benefit would be the improvement of the thermal performance of the wood used in windows

Wood Modification Technologies

- Two forms of wood modification: chemical modification and thermal modification
- Chemical modification requires wood species to have a certain level of permeability otherwise it is not possible to impregnate the wood with the chemical
- Thermal modification – no such limitations!

Chemical Modification

- Sapwood is more permeable than heartwood due to anatomical changes that occur during the transition phase
- European pines and Radiata pine from Chile/New Zealand have a high proportion of sapwood to heartwood (a 80:20 for 30 year old Radiata pine)
- Canadian softwood species have a lower proportion of sapwood to heartwood

Chemical Modification

- Commercially available chemically modified wood sold in Canada use Radiata pine sapwood
- Accoya Wood is the key one available here (uses acetic anhydride in the acetylation process
- Others are not available here (Belmadur Pine, Kebony)
- All of the above are safe to use

Thermal Modification - Overview

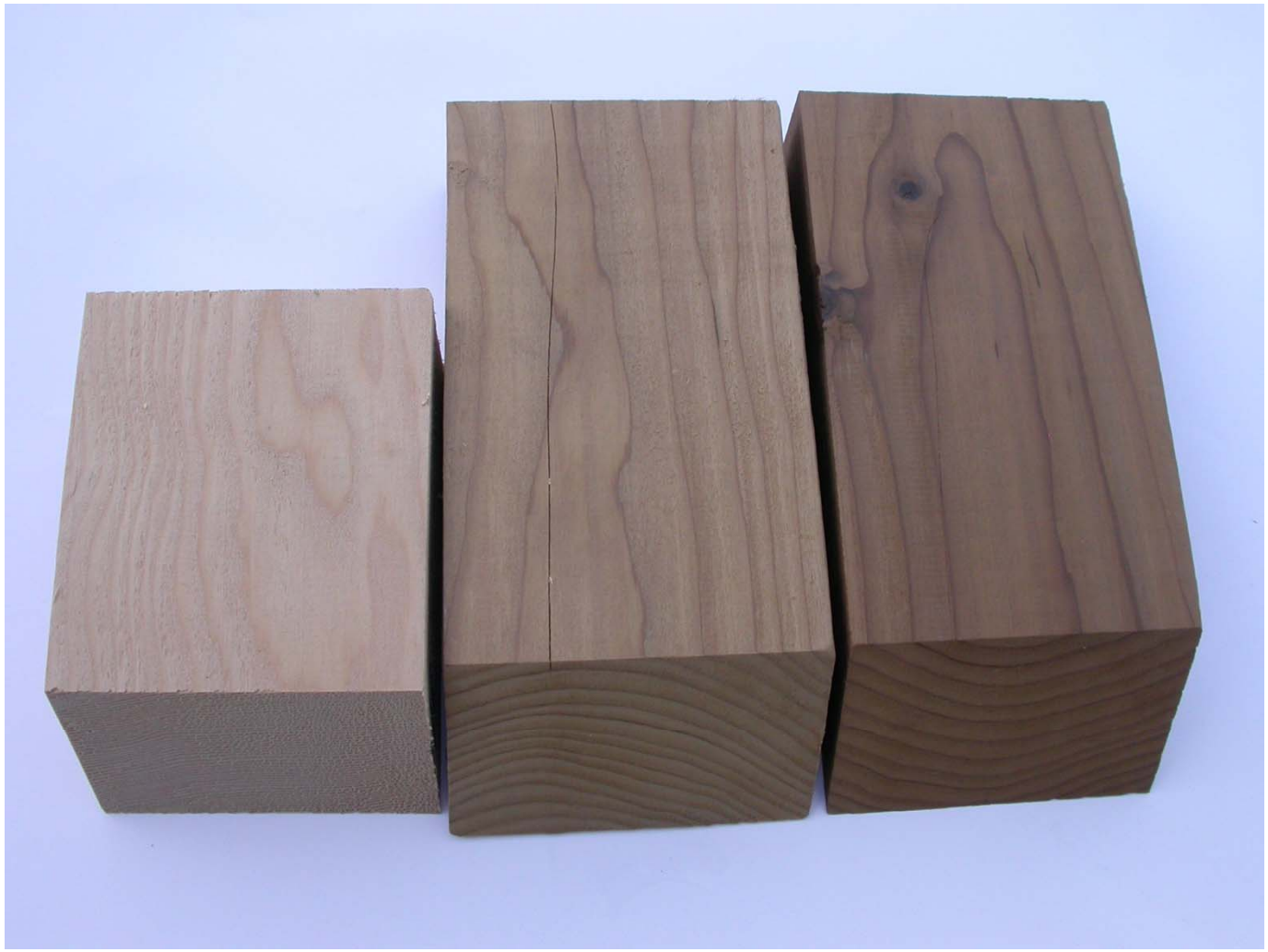
- Most of the research performed in Scandinavia on Scots pine and Norway spruce
- Involves the use of heat (180 to 240ºC) in a specially designed chamber with a low oxygen environment – a chamber exists in the Lower Mainland
- Performed after normal kiln drying

Thermal Modification Chamber

Thermal Modification - Overview

- High temperatures change the chemical composition of the wood cell walls
- Wood colour is darker
- Resulting in mass loss, one of the most important feature
- Can be applied to any wood species and any type of wood (heartwood/sapwood)
- No chemicals are added!

Colour Changes



Thermal Modification - Benefits

- Reduction in the amount of fungi susceptible material ➔ higher durability
- Reduction in the concentration of water-absorbing hydroxyl groups (bonding sites) ➔ dimensional stability increases
- Extractives are evaporated off during the process ➔ no pitch bleed-through but residual surface stains
- Lower density ➔ lower thermal conductivity

Thermal Modification - Negatives

Lower density downside:

- Reduced physical strength (MoE, MoR)
- Reduced fastener withdrawal strength
- Increased brittleness
- Reduced hardness
- Wettability is decreased

All downsides dependent on temperature of treatment, its duration and wood species

Thermal Modification and Moisture

Thermal modification makes wood more hydrophobic:

- Lower equilibrium moisture content for the same conditions (20ºC, 65%RH)
- Reduced water uptake (side grain and end grain orientation)
- Reduced shrinkage and swelling properties

Thermal Modification and Moisture

Effects of decreased wettability:

- Gluing with water based adhesives can become an issue as absorption time increases, other adhesives may not affected the same
- Similarly, water-based coatings are affected the same
- Formulation changes can counteract this

Research Conducted in Canada

- Duplication of Scandinavian testing, carried out on jack pine and balsam fir by FPInnovations' Quebec lab – similar findings
- Initial durability test (soil block test) done on thermally modified Douglas-fir heartwood to determine if this moderately durable wood can be improved – no increase in durability classification

Soil Block Test

Research Conducted in Canada

- Recently completed testing of the physical and other properties evaluation of western hemlock and amabilis fir for two treatment temperatures
- Intent was to determine properties of tight knot lumber for decking
- Shop grade of hemlock and A. fir added to gauge relevance for the window/door industry

Research Conducted in Canada

Findings:

- Reduction in equilibrium moisture content for same conditions (more hydrophobic)
- Reduced shrinkage and swelling
- Reduced capillary uptake of water
- No resulting loss of mechanical strength (MoE, MoR)
- Marginal density loss

Research Conducted in Canada

- Decrease in fastener withdrawal force especially screws
- Coating adhesion was reduced using generally available primer/topcoat
- Surface machining properties not affected
- Higher treatment temperature influenced results

Current Research Projects

Need more definitive durability test results

Just launch a durability study

- Painted L-joint field test
- Standard laboratory test and accelerated tests of a 3 to 5 year duration as compared to WRC
- Answer the question “How much more durable?”

L-joint Test

Current Research Projects

Thermally modified wood windows:

- Follow-up with previous work on hemlock
- Looking at hemlock and Douglas-fir
- Thermal conductivity and durability of paint coating
- Comparative test of thermal conductivity from same original sample of lumber for two treatment temperatures

Current Research Projects

- Use these values in a therm model to determine U value improvement by used thermally modified wood
- Coating tests use generally available coating systems and specifically formulated coatings
- Adhesion test and weather machine test for 1000 hours to determine UV effects and cracks in coatings

Current Research Projects

- Test results by next summer
- 2 windows constructed from these two wood species

Future Research

- Optimize treatment schedule for each specific wood species and application (windows, siding and other exterior wood products)
- Optimize for durability, gluing, coating adhesion, dimensional stability
- Quality Control: how to determine optimized schedule is attained

Questions