Field Study of Long-Term Durability of Wood Plastic Composites

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WPC Manufacturing - USA

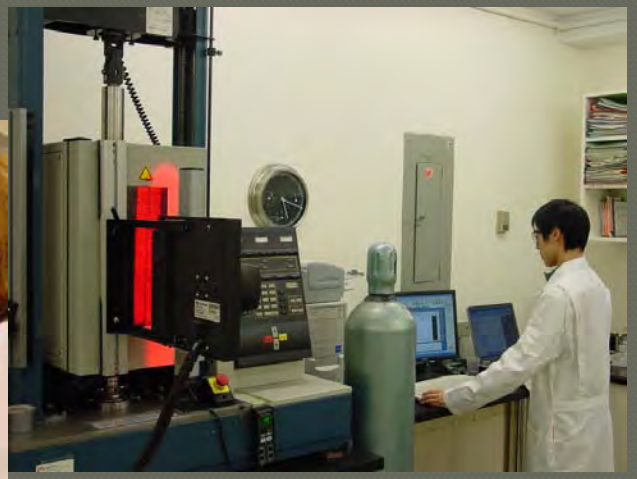
Decking and fencing – 51%
Moulding and trims - 39%
Windows and doors - 4%
Others - 6%

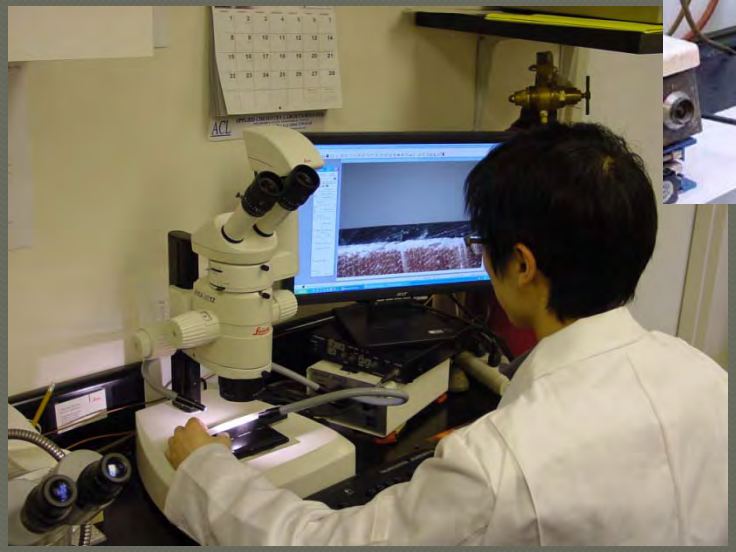
WPC sales are expected to advance 10.5 – 11.1% annually thru 2013*

*Freedonia report

Construction with WPC

Polymer Engineering



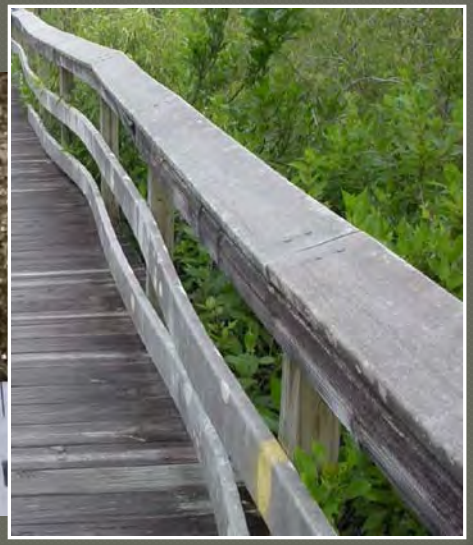


Water in WPC

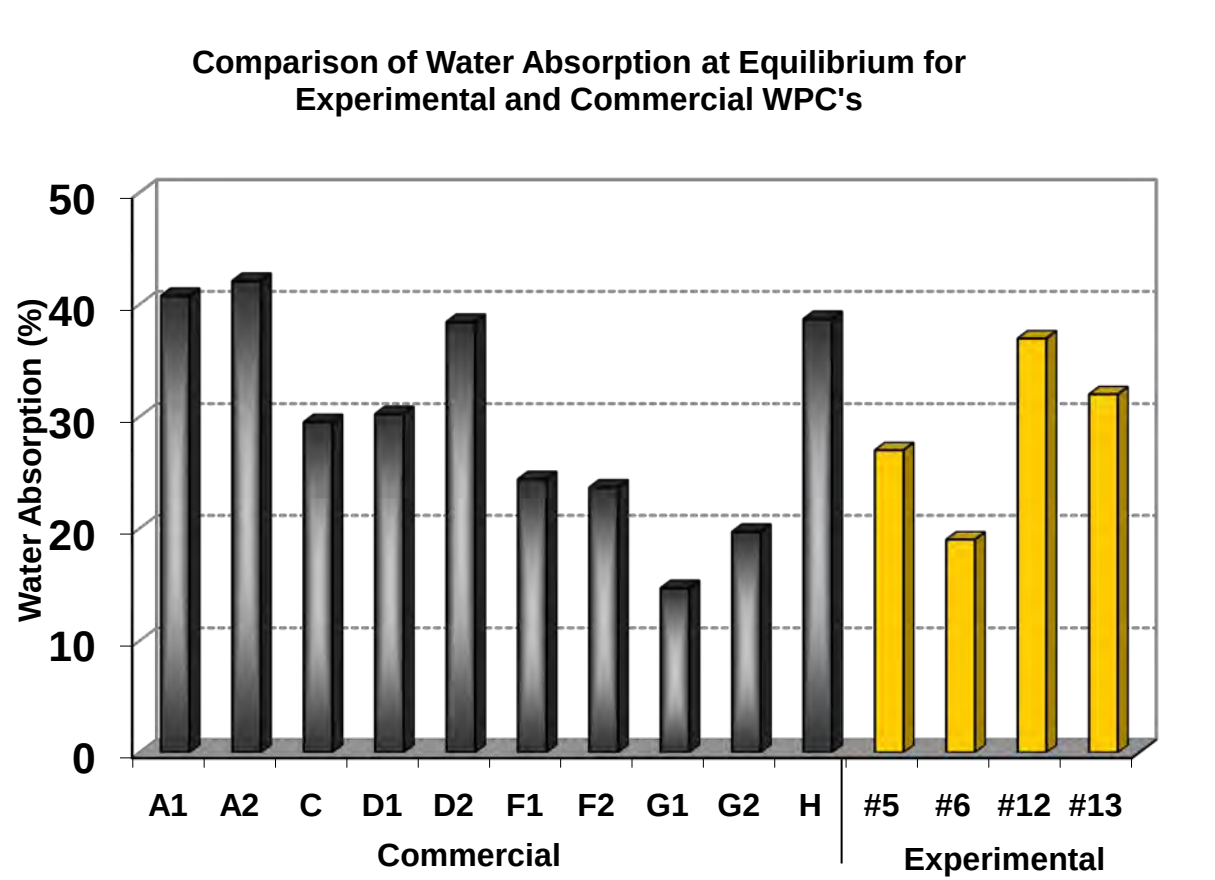
Wood particles are encapsulated in plastic

Polyethylene water saturation ~0.01%

Wood fiber water saturation ~25%



Experimental WPC

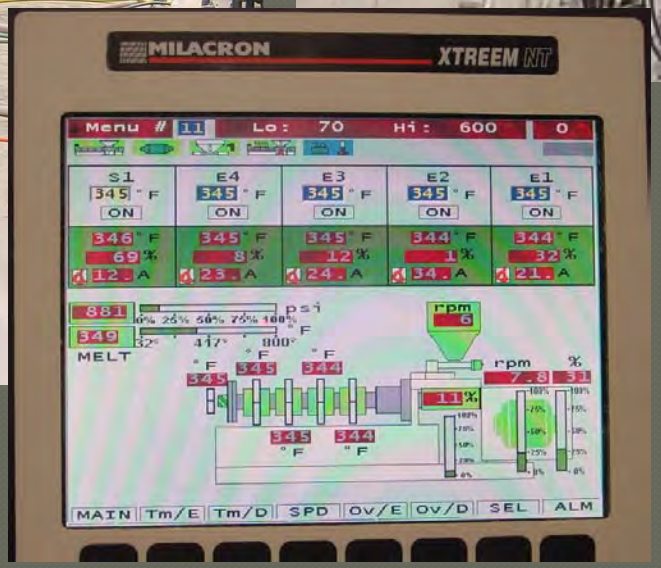


Experimental WPC

Ingredients	Formulation ID #													
	1	3	4	5	6	8	10	11	12	13	27	28	31	33
Wood - Pine	50	50	50	50	50	65	65	65	65	65				
Wood - Oak											50	50	65	65
HDPE	45	45	45	45	45	30	30	30	30	30	45	45	30	30
Talc %	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lubricants %	3	3	3	3	3	3	3	3	3	3	3	3	3	3
UV Stabilizer	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Zinc Borate %	0	2	3	0	3	0	2	3	0	3	3	0	0	0
Board Cross-section (inches)	6 x ½	6 x ½	6 x ½	6 x ½	6 x ½	6 x 1	6 x 1	6 x 1	6 x 1	6 x 1	6 x ½	6 x ½	6 x 1	6 x 1

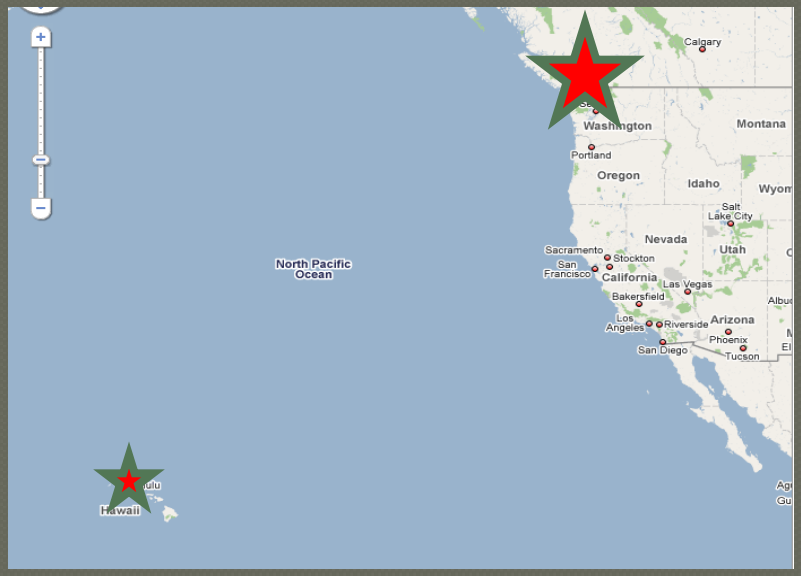
Quantities are approximate

Experimental WPC



Exposure Locations

Hilo, Hawaii



Vancouver, BC

Exposure Locations

Vancouver, BC

Annual Weather Data

precipitation: 1118 mm
average low temperature: 0°C (January)
average high temperature: 23°C (July)
hours of sunshine: 1950
pan evaporation: 22 (Bellingham, WA)

Scheffer index: ~50

Exposure Locations

Hilo, Hawaii

Annual Weather Data

precipitation: 3200 – 5100 mm
minimum temperature: 12°C
maximum temperature: 34°C
hours of sunshine: 2100
pan evaporation: 91 (Honolulu)

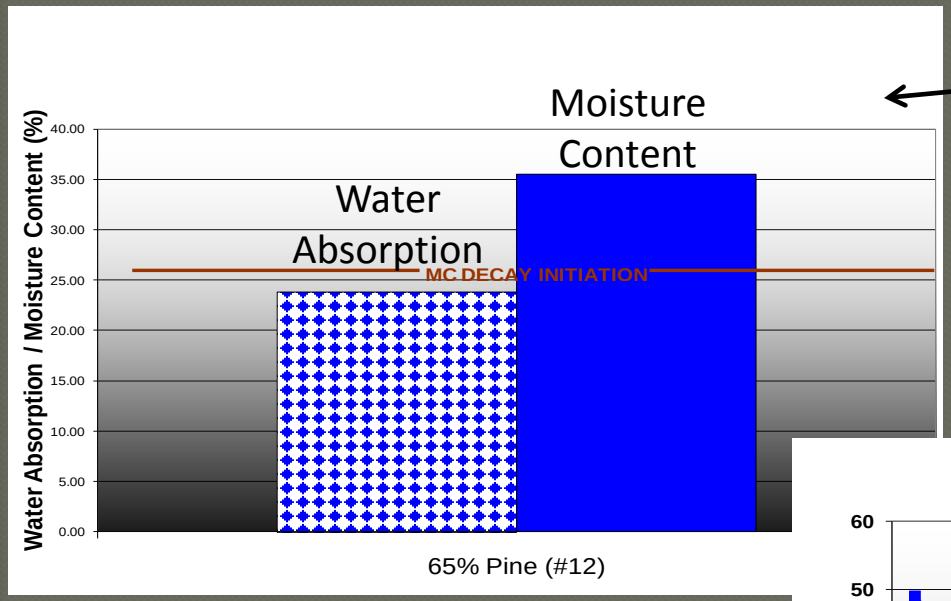
Scheffer index: ~330

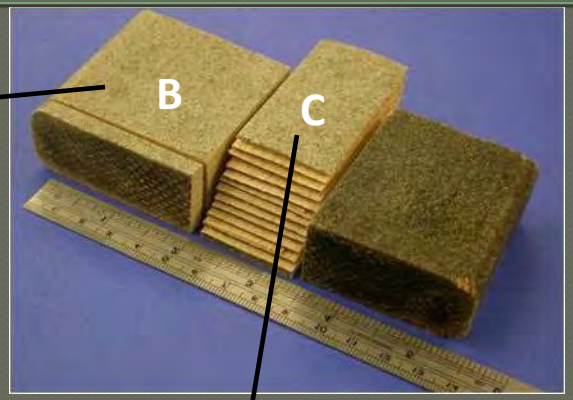
The Scheffer Index

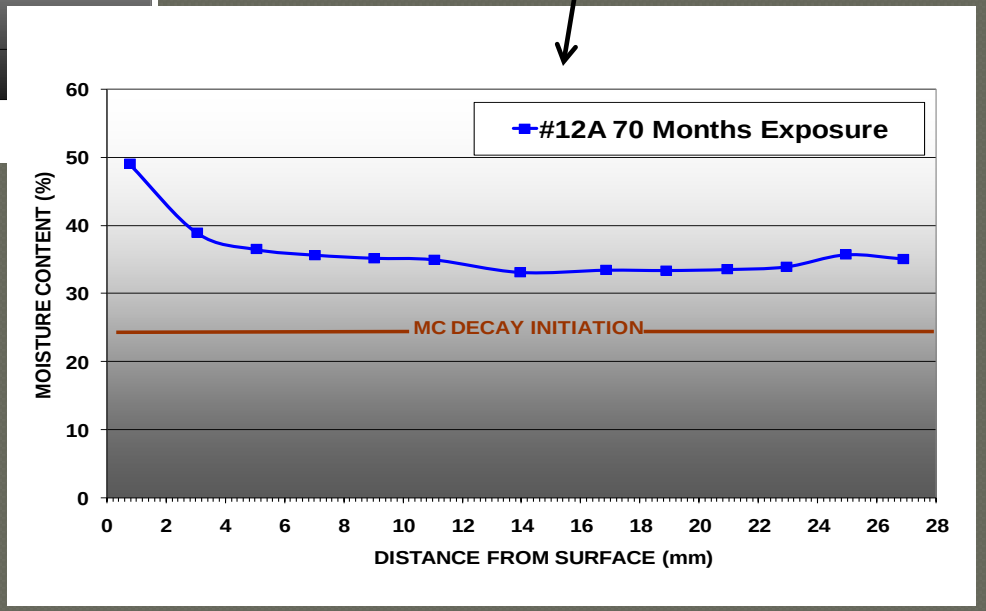
Location	Scheffer Index*
Vancouver, B.C.	~50
Prairie Provinces	~35
Denver, CO	~35
Phoenix, AZ	~7
Wilmington, NC	~80
Miami, FL	~120
Hilo, HI	~350

*Tool for quantifying climatic exposure conditions and predicting wood above-ground performance – based on Average Annual Temperature and the # days/month with measurable precipitation

Sample Evaluation

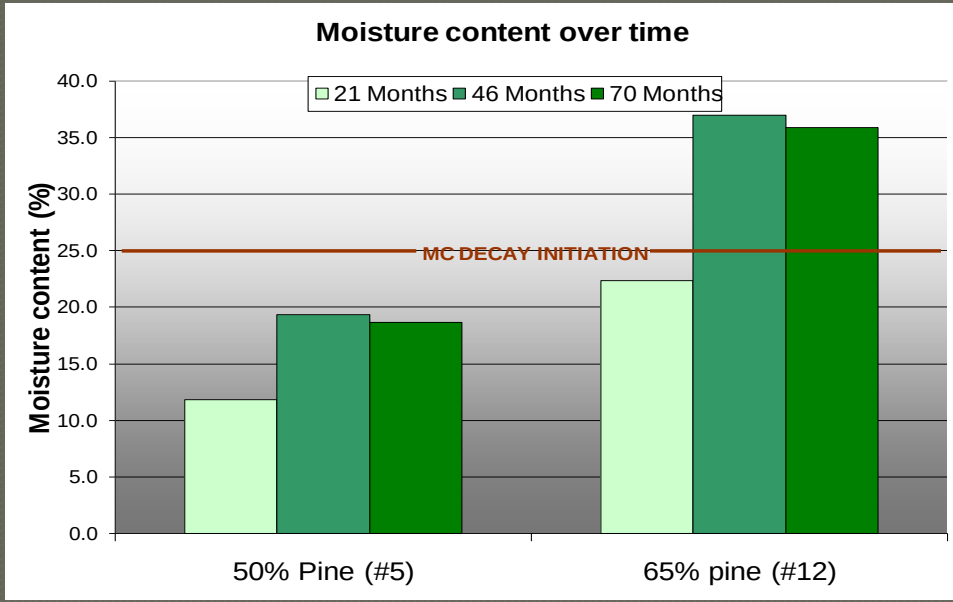


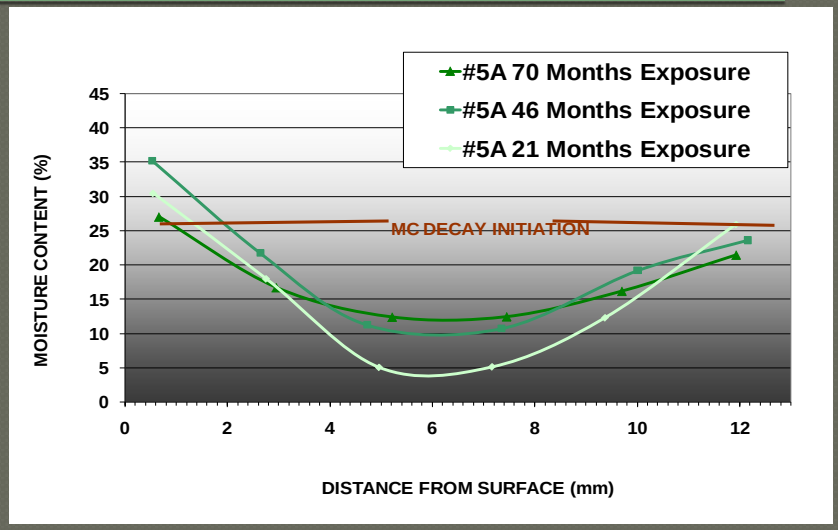


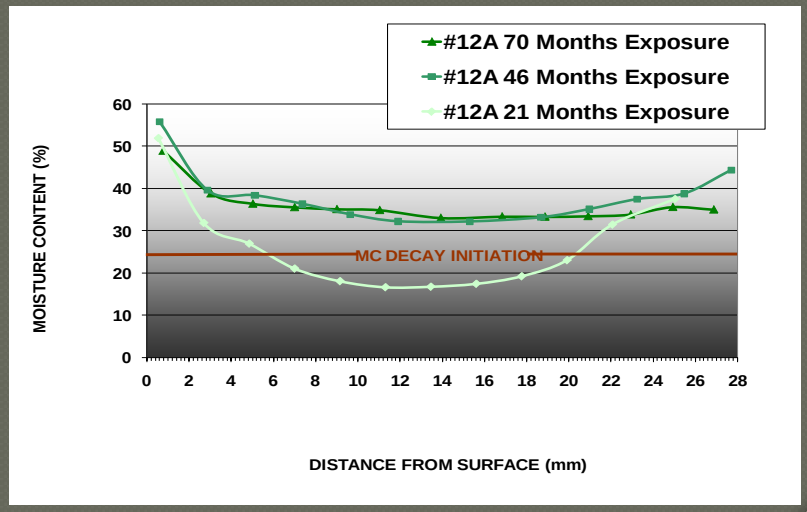


Period of Exposure

Sunny Exposure in Vancouver, BC

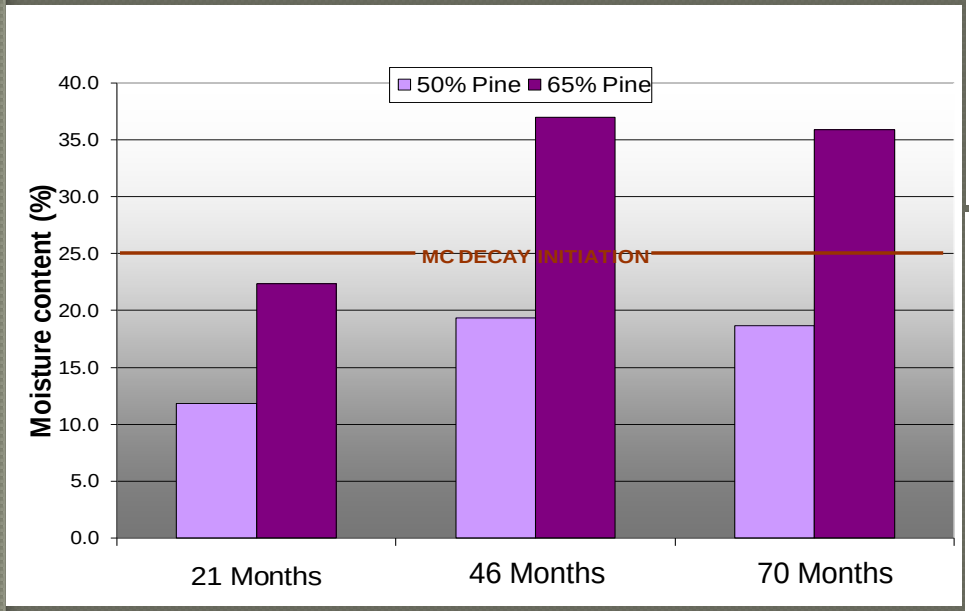


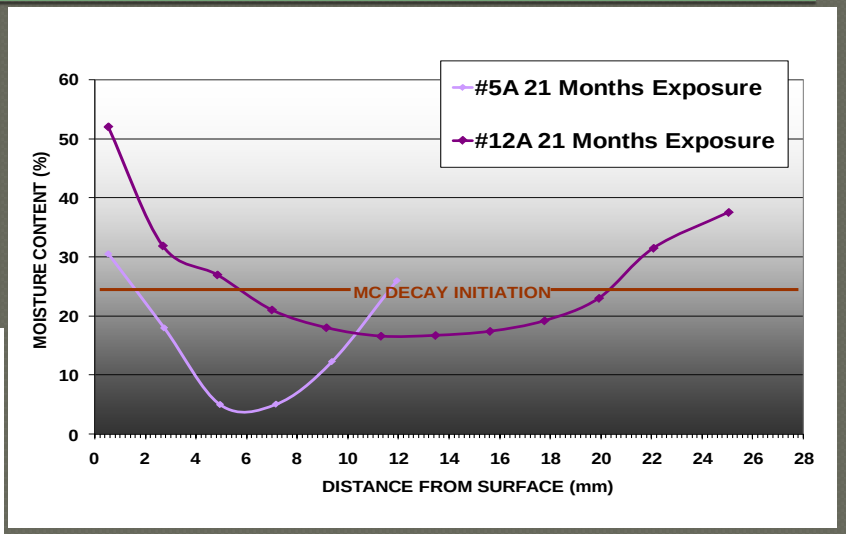


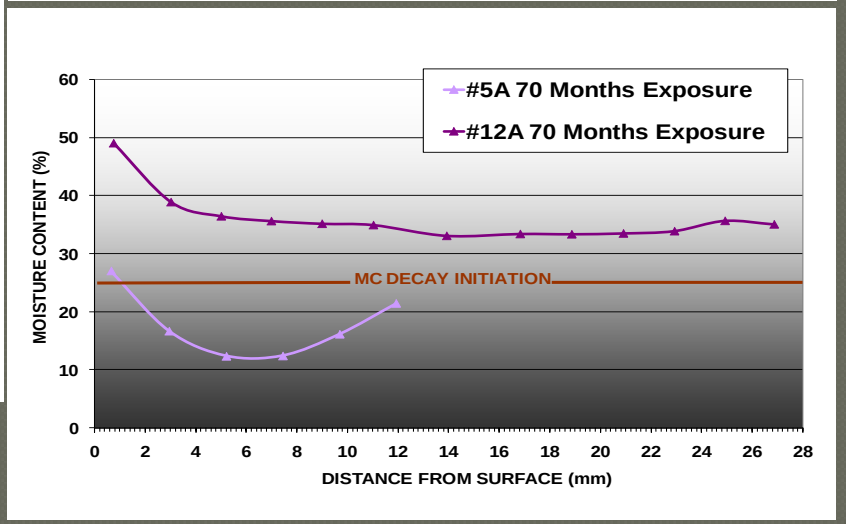


Wood Content in WPC

Sunny Exposure in Vancouver, BC

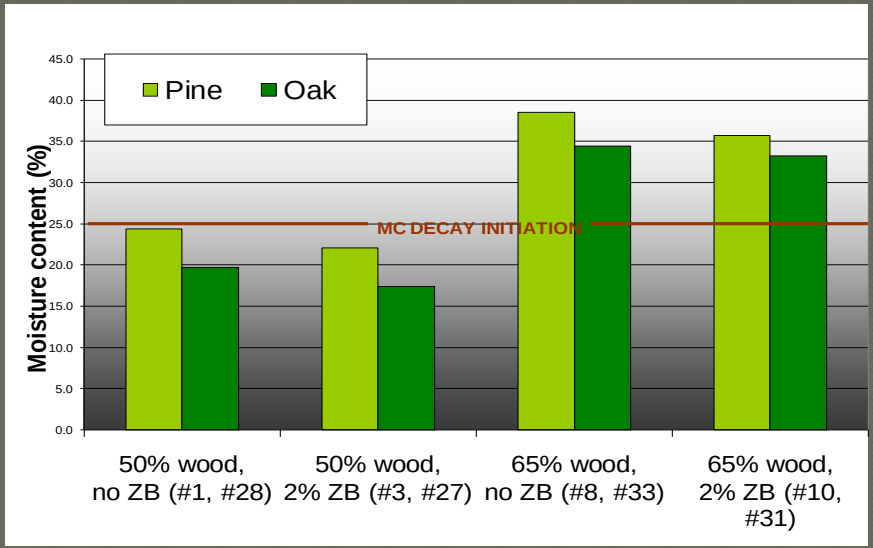


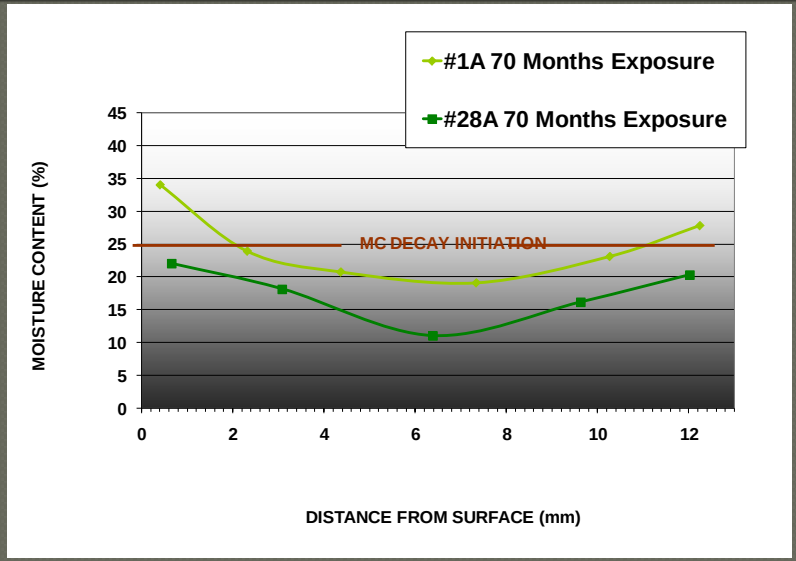


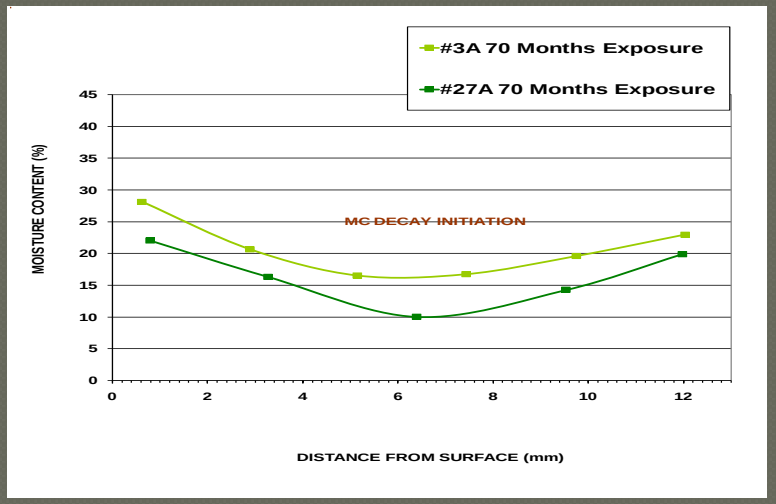


Wood Species

Sunny Exposure in Vancouver, BC (70 months)

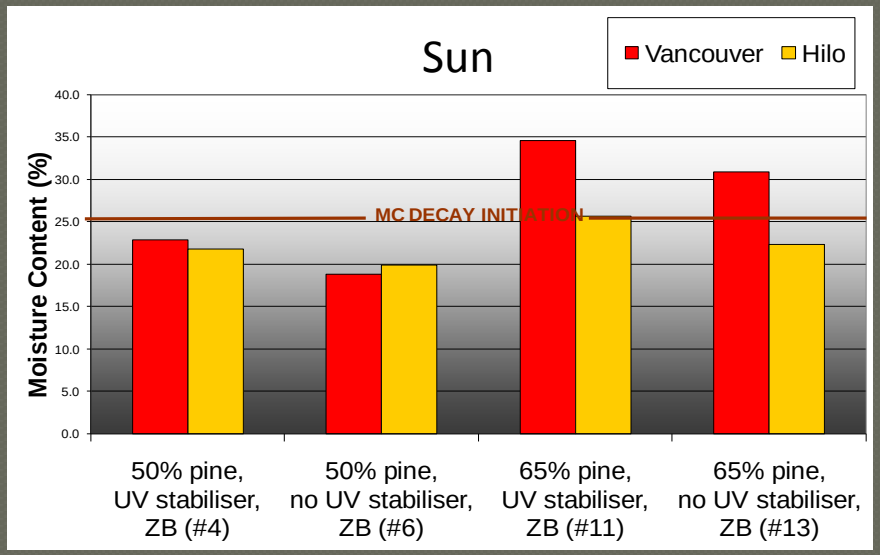


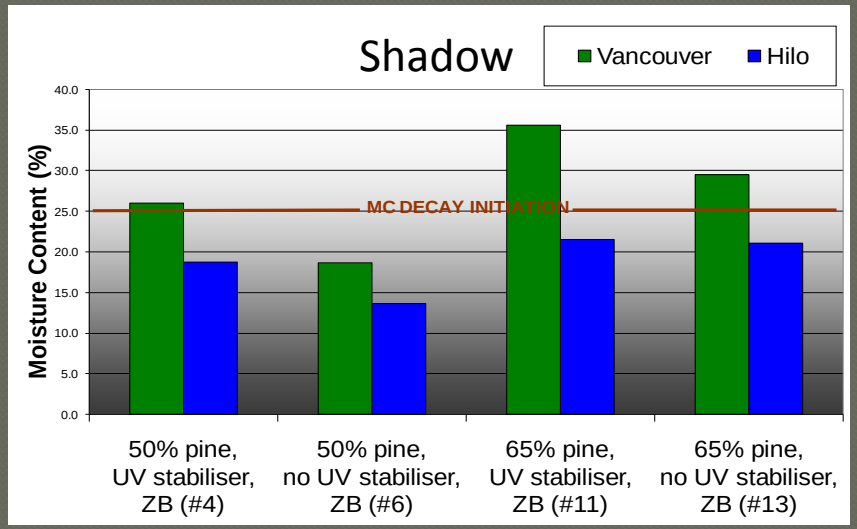


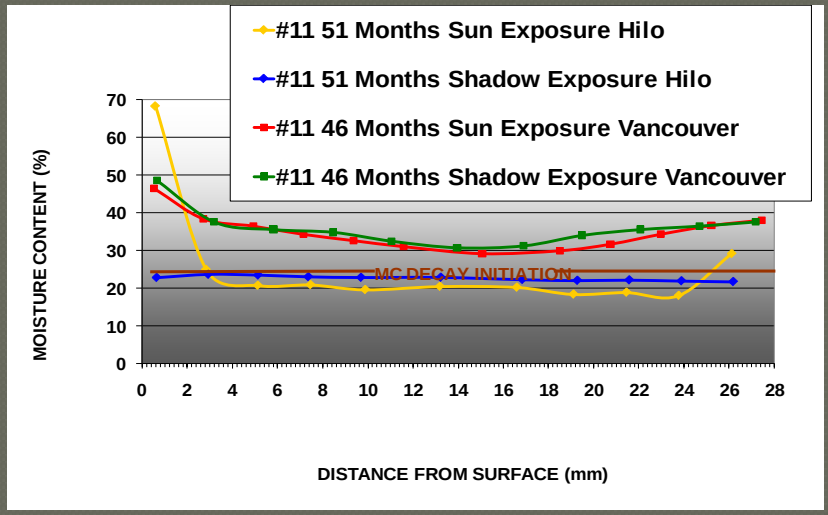


Geographical Location

Exposure in Vancouver, BC
(46 months)
and Hilo, Hawaii (51 months)

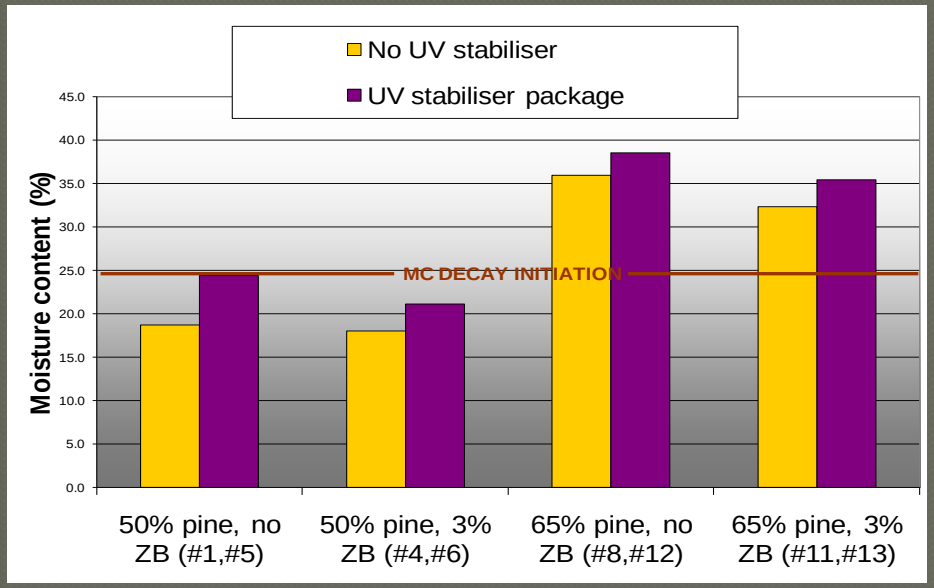


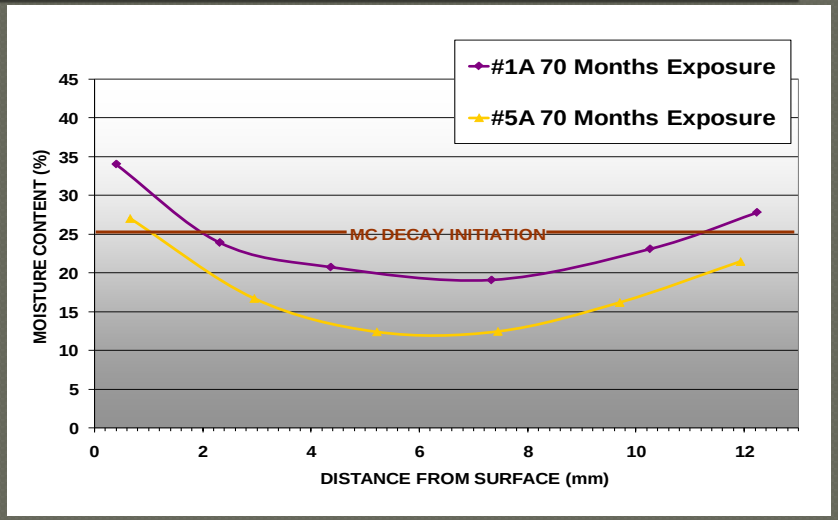


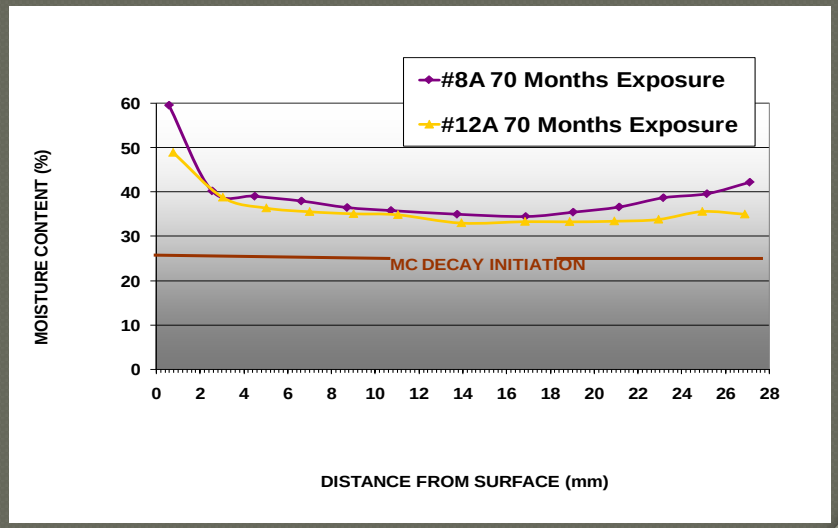


Presence of UV Stabilizers

Sunny Exposure in Vancouver, BC (70 months)

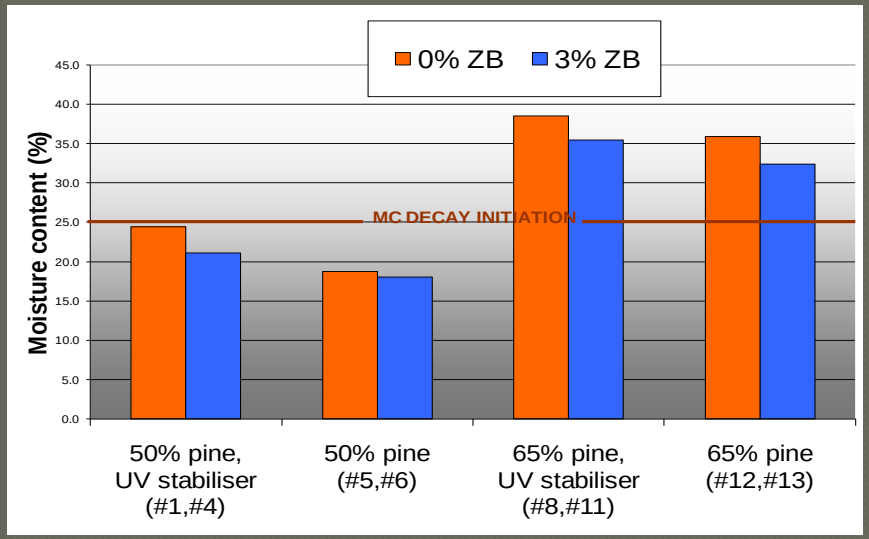


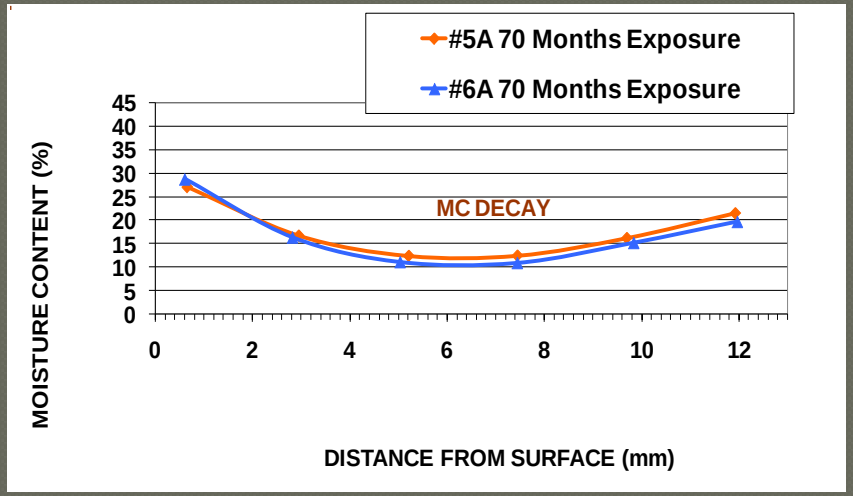


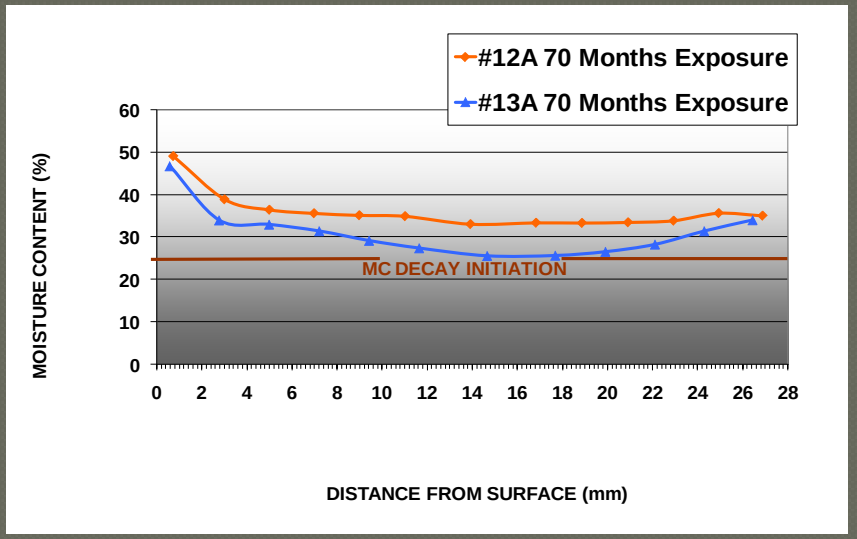


Presence of Zinc Borate

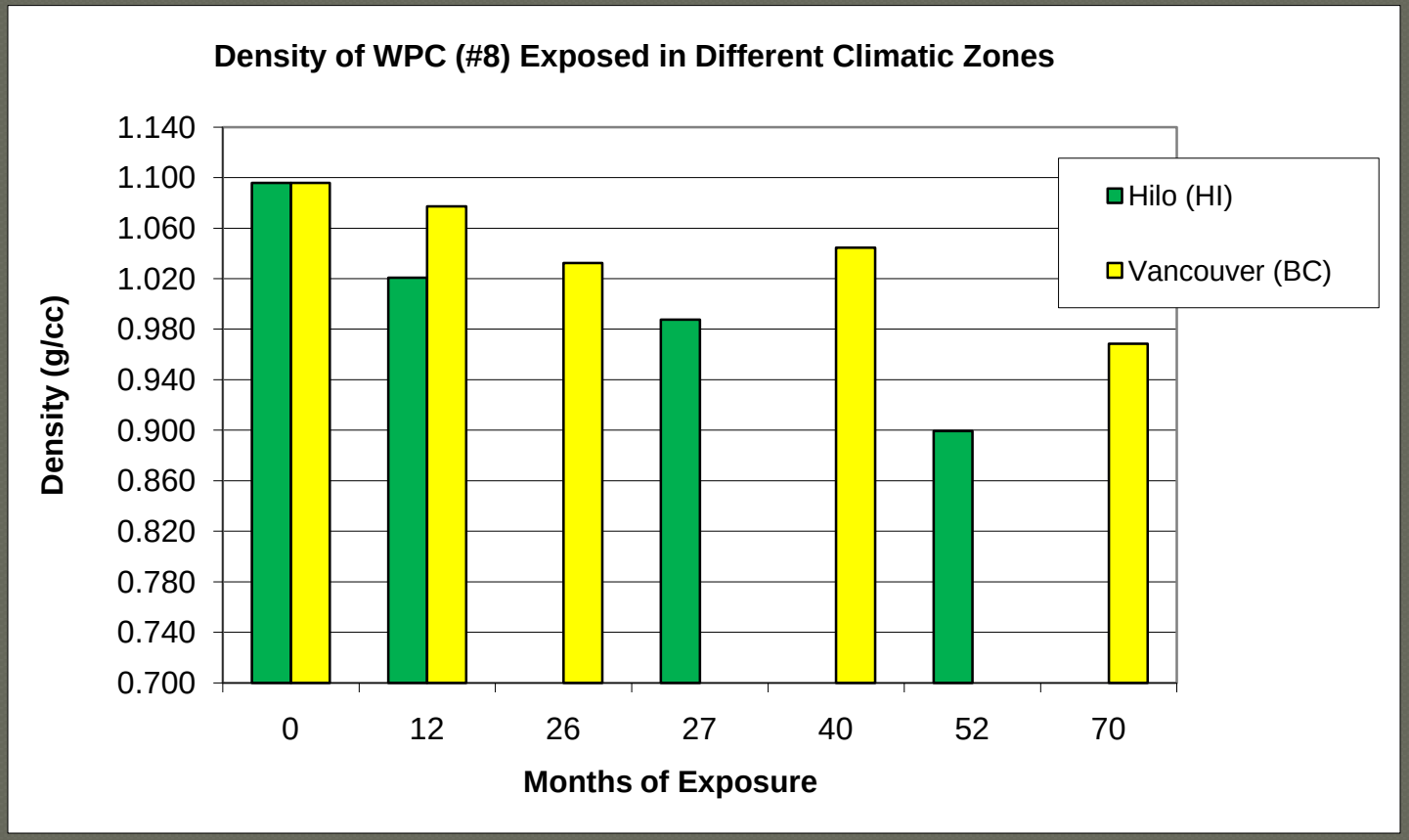
Sunny Exposure in Vancouver, BC (70 months)

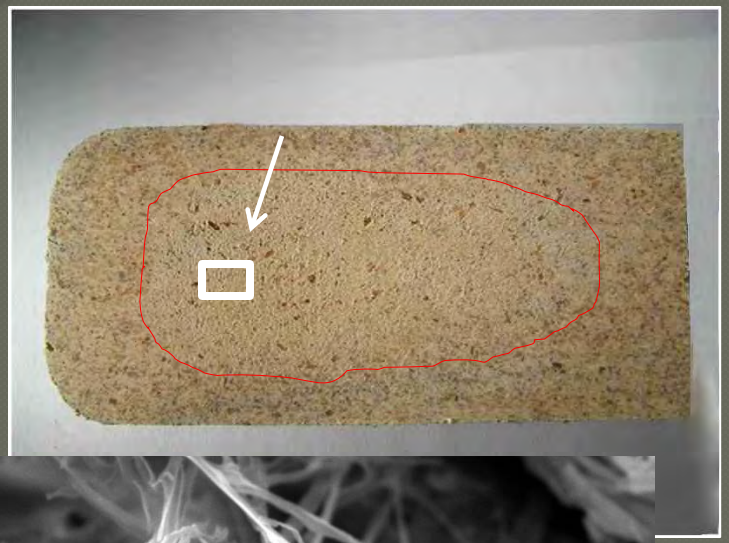


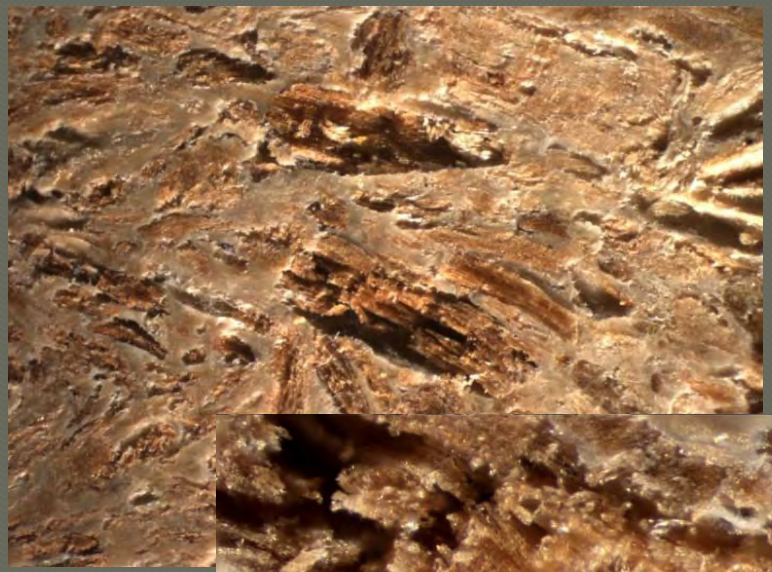


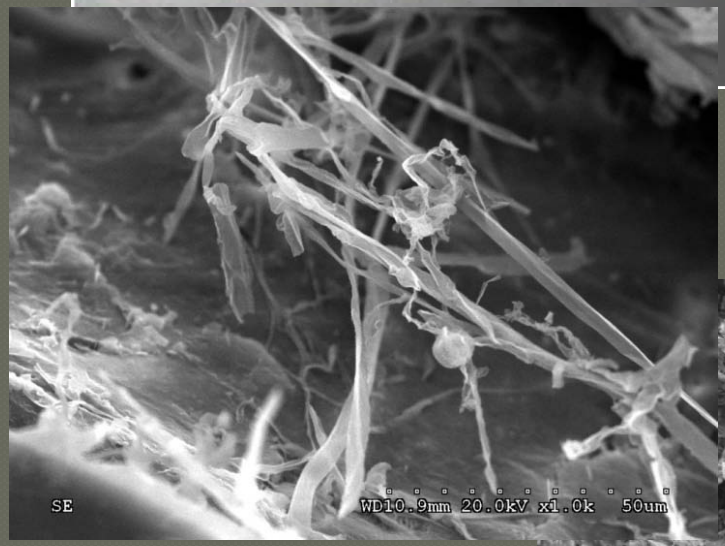


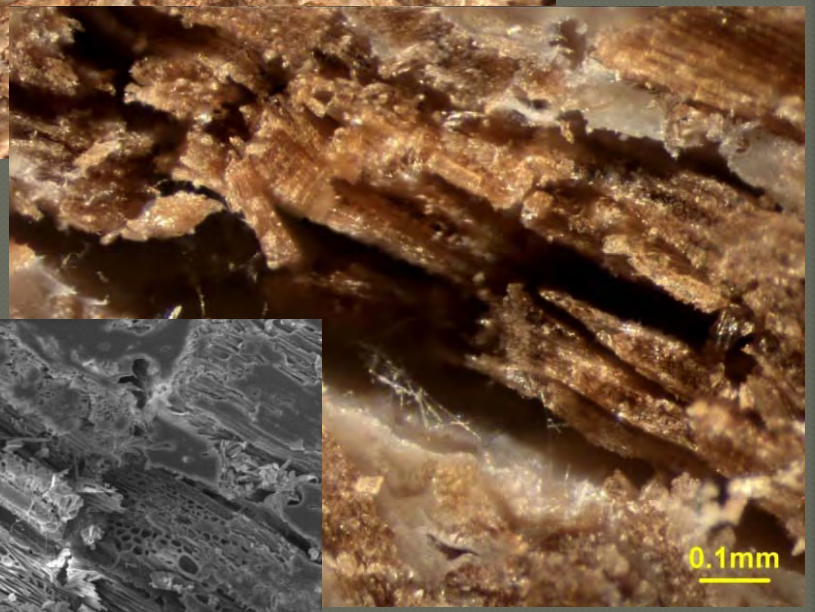
Change in WPC Density

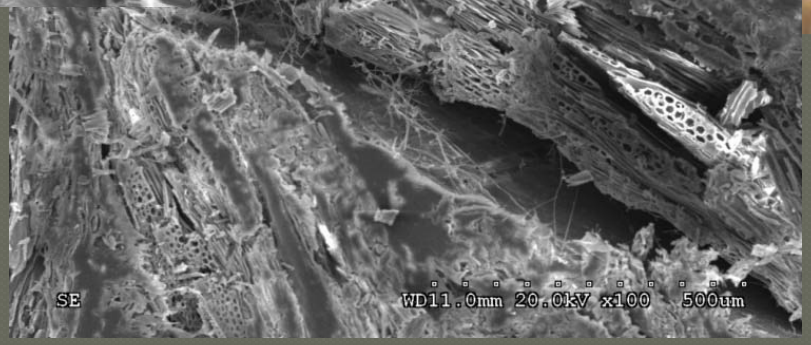




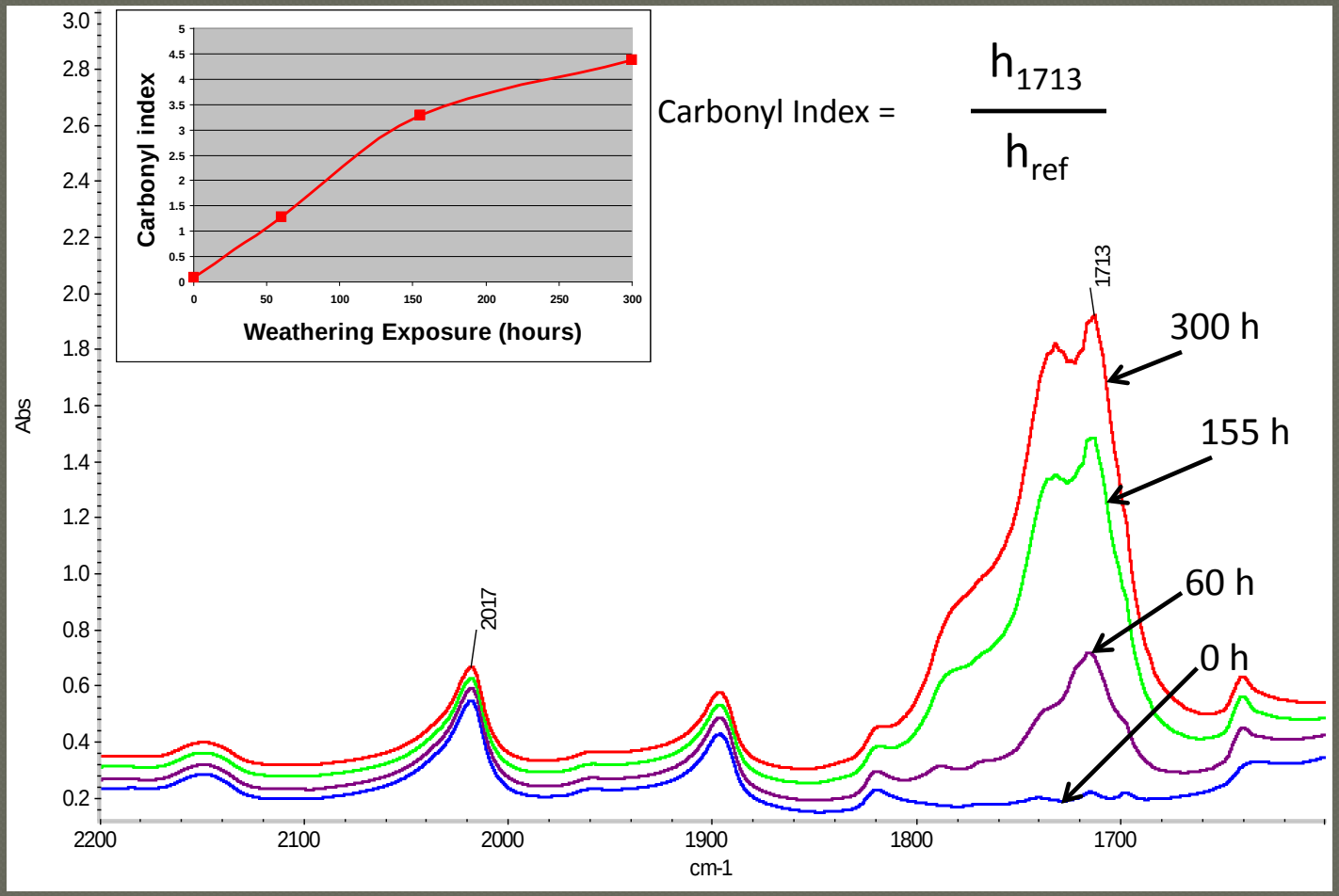



SE
WD10.9mm 20.0kV x1.0k 50um

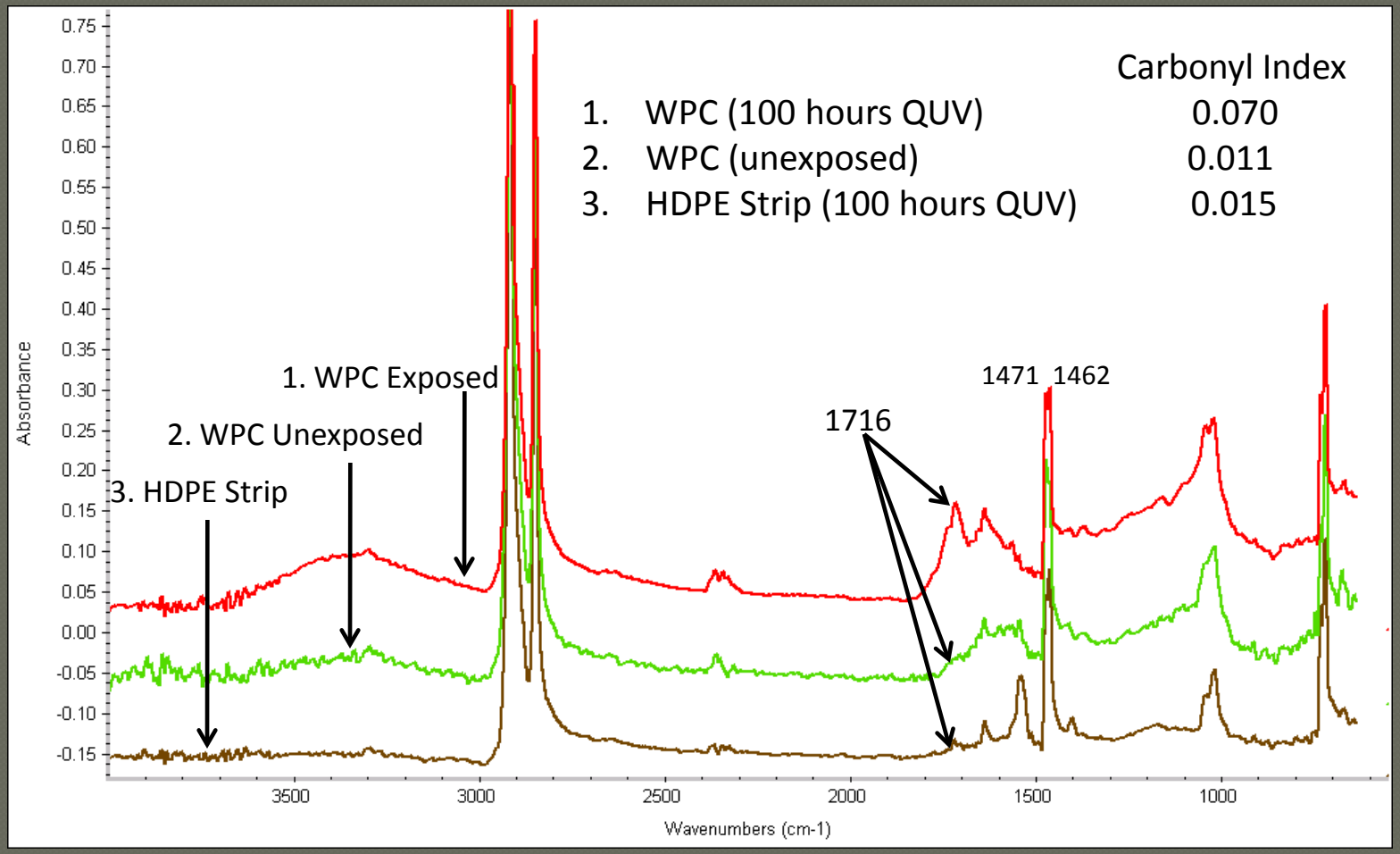

0.1mm


SE
WD11.0mm 20.0kV x100 500um

Carbonyl Index



Carbonyl Index HDPE vs WPC



36 Months Exposure in B.C.

Carbonyl Index:

0.237 (36 months)

0.140 (4 months)

Pine 50%

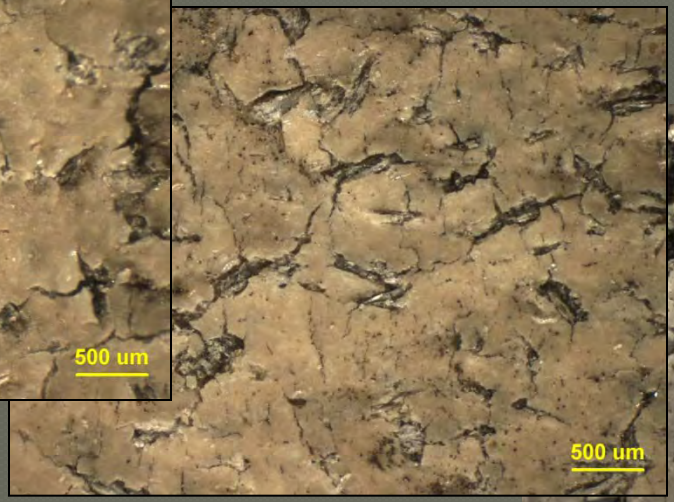
UV Stablizer

Zinc Borate 3%

Carbonyl Index:

0.244 (36 months)

0.179 (4 months)



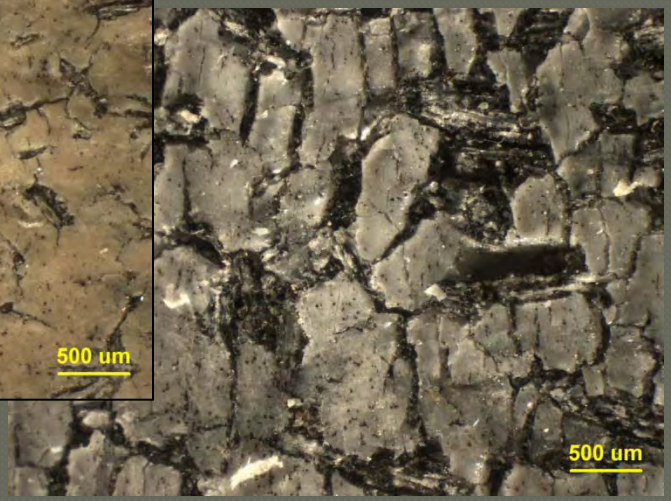
Pine 50%

UV Stablizer

Carbonyl Index:

0.246 (36 months)

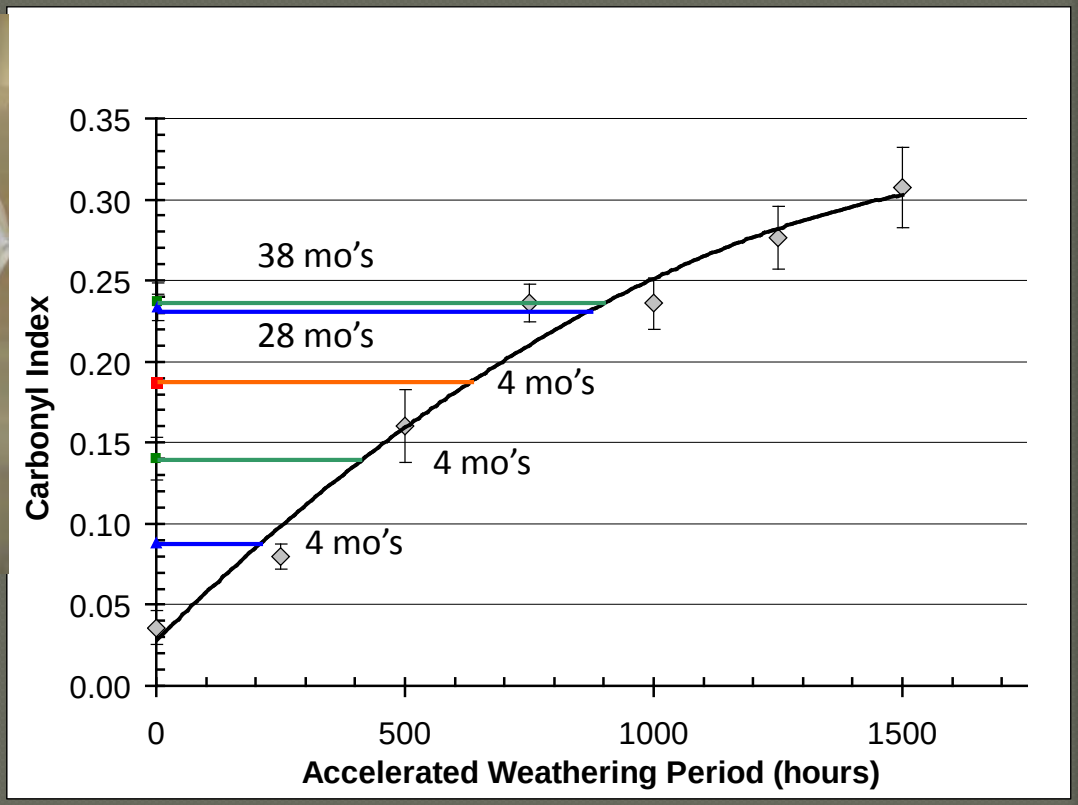
0.234 (4 months)



Pine 50%

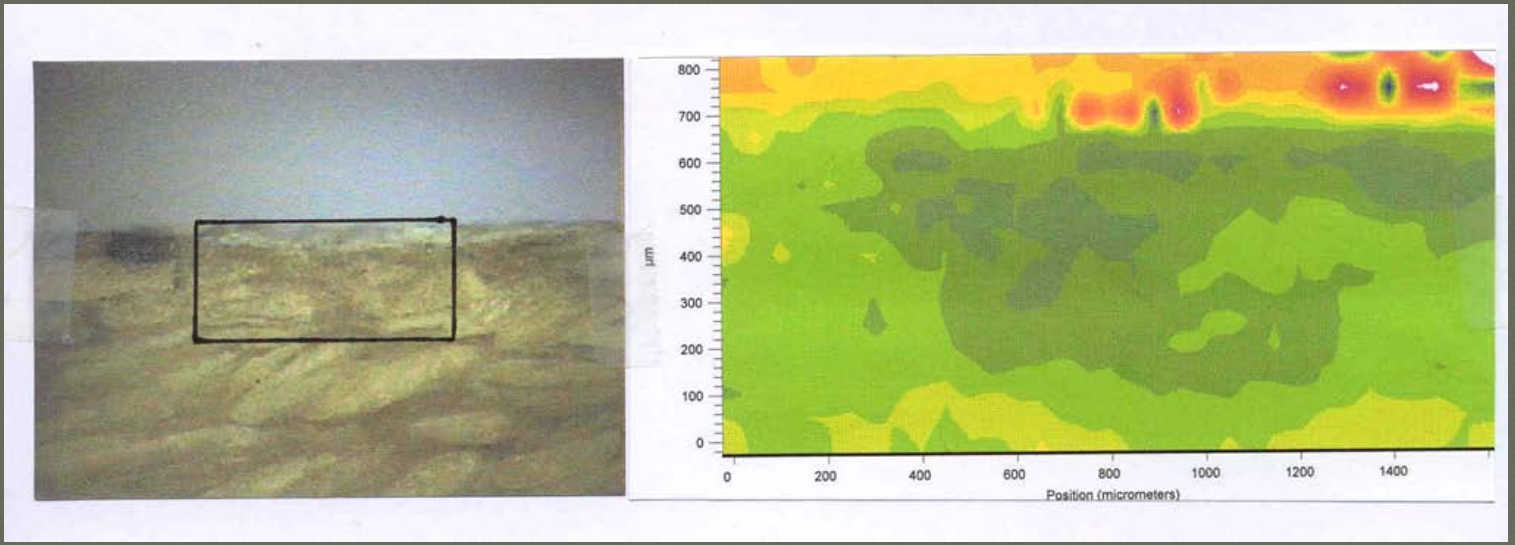
Correlation of Accelerated Weathering to Exterior Exposure

UVB 340 lamps
irradiance 0.77 W/m^2/nm
8 hours of light (60^{o}C)
4 hours of condensation (50^{o}C) cycle)



Depth of UV Degradation 2000h QUV

Raman spectroscopy* oxidized HDPE layer thickness ~0.6 mm



* Courtesy Thermo Nicolet

Conclusions

Wood Plastic Composite (WPC) boards progressively absorb a significant quantity of water during exterior exposure. Moisture content distribution in the board cross-sections has a characteristic U-shape, frequently exceeding the concentration required for decay initiation. Decay was observed for some samples exposed in extreme conditions.

A major factor in water absorption by WPC was the ratio of wood to plastic binder; with the increase of wood content, moisture content progresses very quickly. Another factor in water absorption is the composition of WPC. Certain additives may significantly increase or decrease water absorption (for example zinc borate decreased water absorption in the tested formulations). Climate may not be a major factor here.

Various FTIR techniques can be used to track the oxidative degradation of polyethylene binder in WPC. Analysis of FTIR spectroscopic data can be used for assessment of the relative progress of weathering and the effect of different additives. FTIR analysis of WPC after a few months of exterior exposure may serve as an indicator of long-term performance.

Wood can accelerate photo-oxidation of polyethylene in WPC. The intensity of the process seems to be related to wood species. WPC degradation by UV light seems to be only a surface and shallow subsurface phenomenon

•Some additives commonly used in WPC may have a positive or negative effect on polyethylene photo-oxidation. Zinc borate can be seen as an example of a biocidal additive which also inhibits photo-oxidation.

Acknowledgements

Polymer Engineering staff involved in this research:
- Cecilia Stevens, Ph.D.
- Mathew Leung, B.Sc.
- Kate Mao, B.Eng.
- David Lesewick
- Christine Mah, B.Sc.
- Beverly Start

Washington State University
(Wood Materials and Engineering Lab)

Raman spectroscopy Courtesy Thermo Nicolet