



Managing Aesthetic Expectations from Weathering of Wood Claddings with Clear Finishes

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Outline

- Industry challenges and expectations of weathering of wood claddings with clear finishes
- Weathering test apparatus & documentation protocol
- Example results & key conclusions to date



Why Did We Undertake this Research?

- Wanted to better understand real-world weathering aesthetics of clear finished or unfinished natural wood claddings
- Included traditional durable wood species (cedars) and other soft & hardwoods, different grading/grain orientation, thermally modified wood, chemically modified wood (acetylated and furfurylated) and fire-treated wood
- Help architects specify and design wood and finish combinations
- Set realistic expectations for weathering aesthetics including fungal growth, color, grain distortion, stain deterioration
- Estimate realistic maintenance cycles and activities (cleaning, re-coating, re-finishing) for owners

Wood Claddings are Building Science Litmus Paper;-)



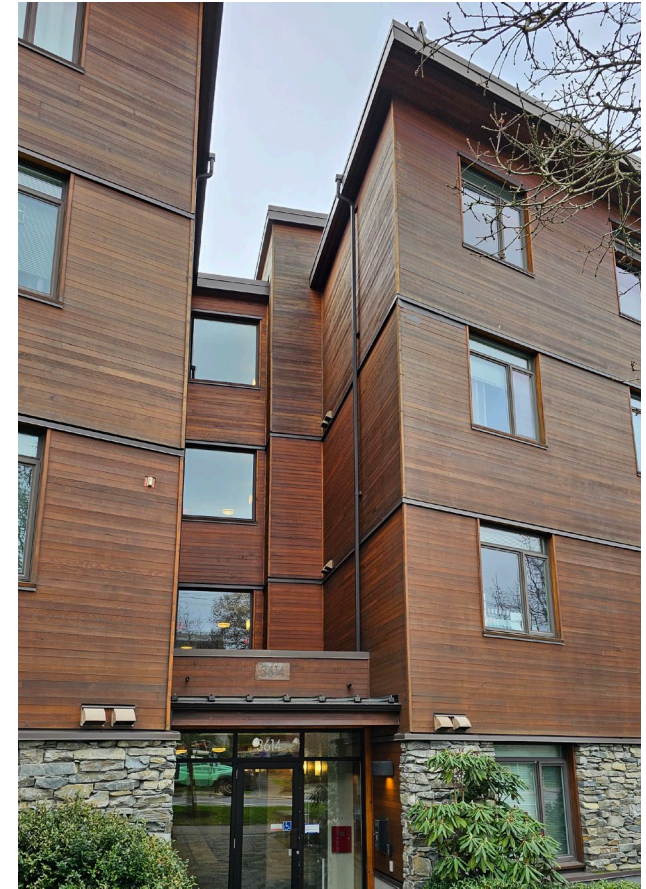
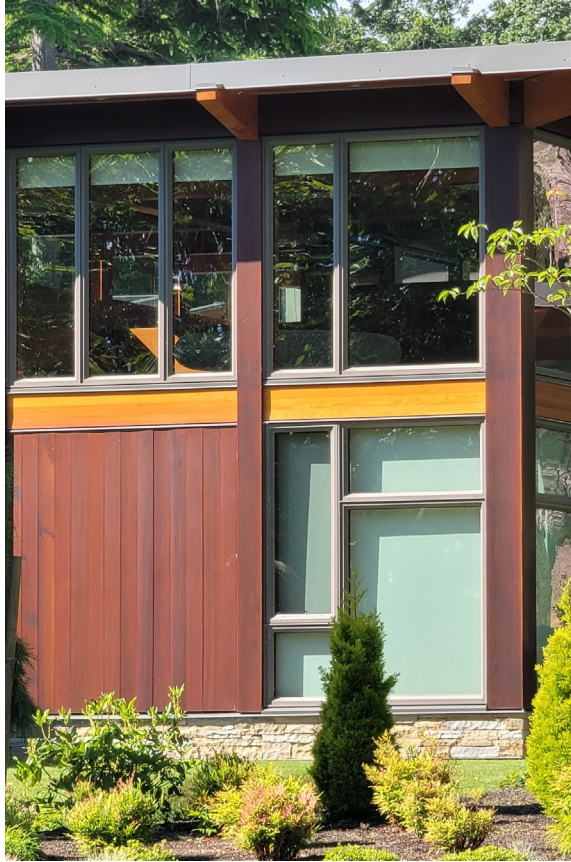
Some of Many Wood Cladding Design Project Drivers



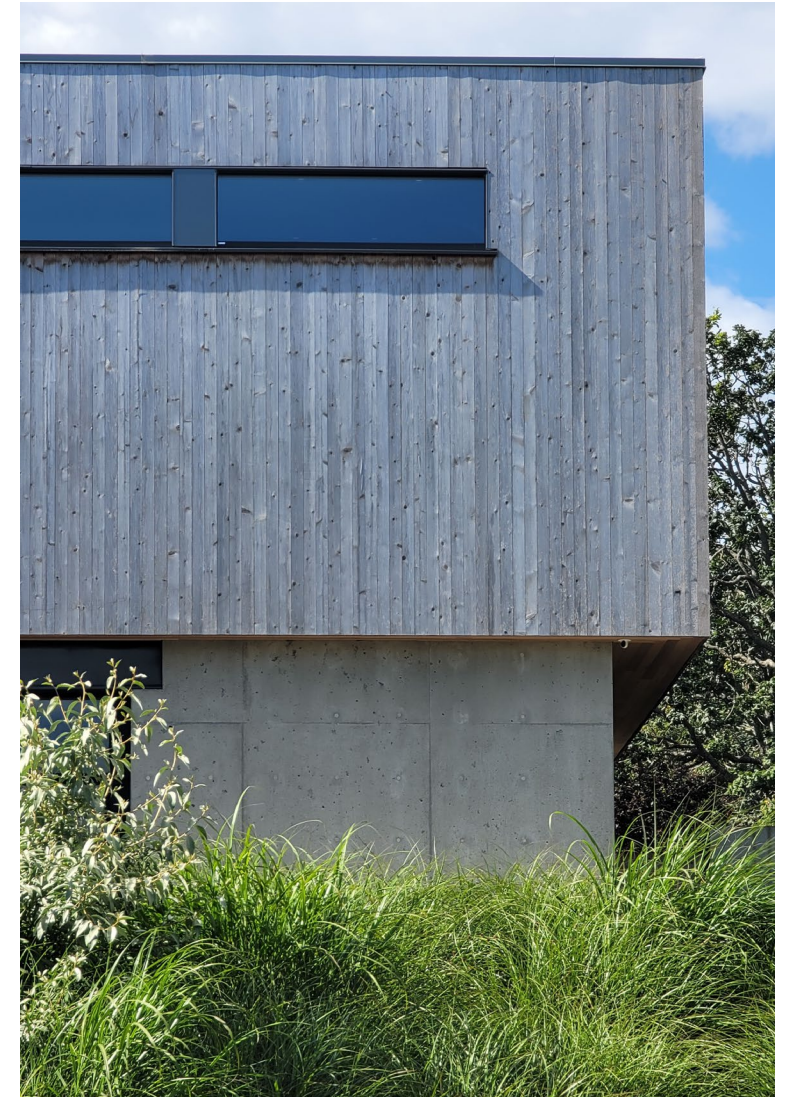
The Desire: Modern Wood Claddings w/ Clear Finishes



The Desire: Modern Wood Claddings w/ Clear Finishes



The Desire: Modern Wood Claddings – Natural Weathering



The Desire: Modern Wood Claddings – Pre-Weathered Appearance but New



The Often Reality After a Few Years



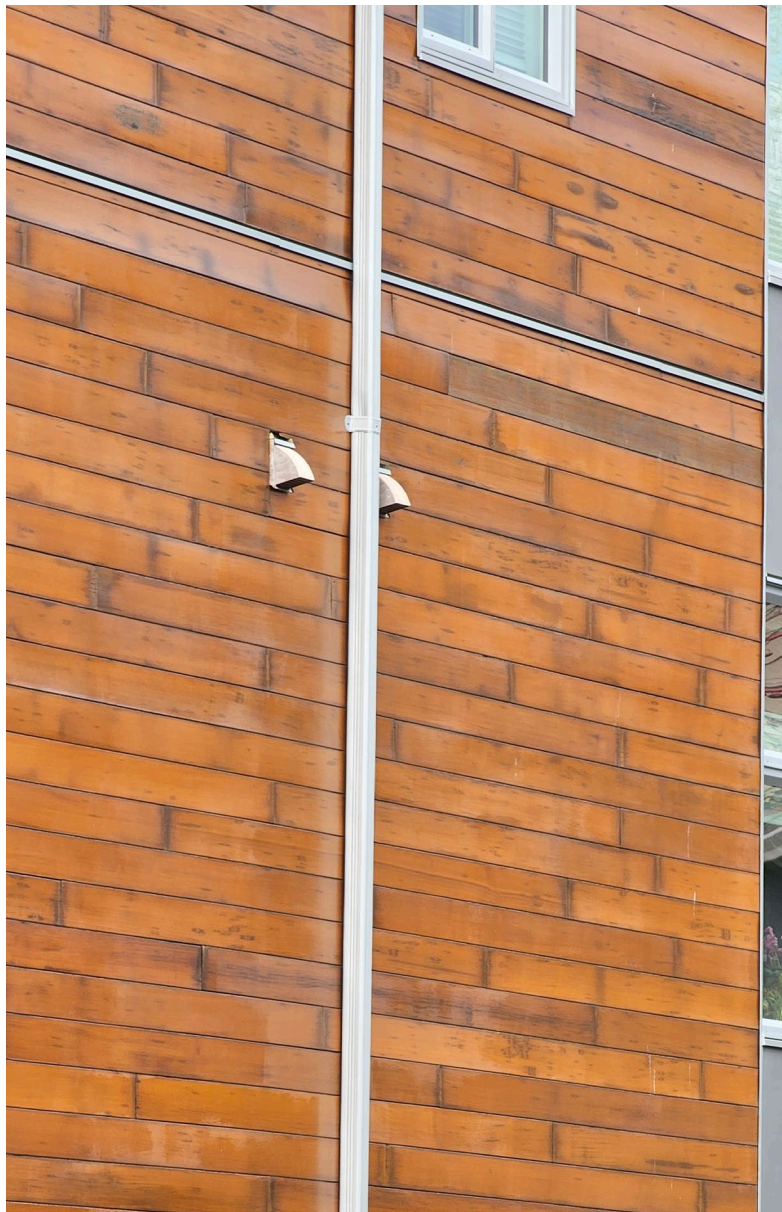
The Often Unfortunate Reality After a Few Years



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The Often Unfortunate Reality After a Few Years



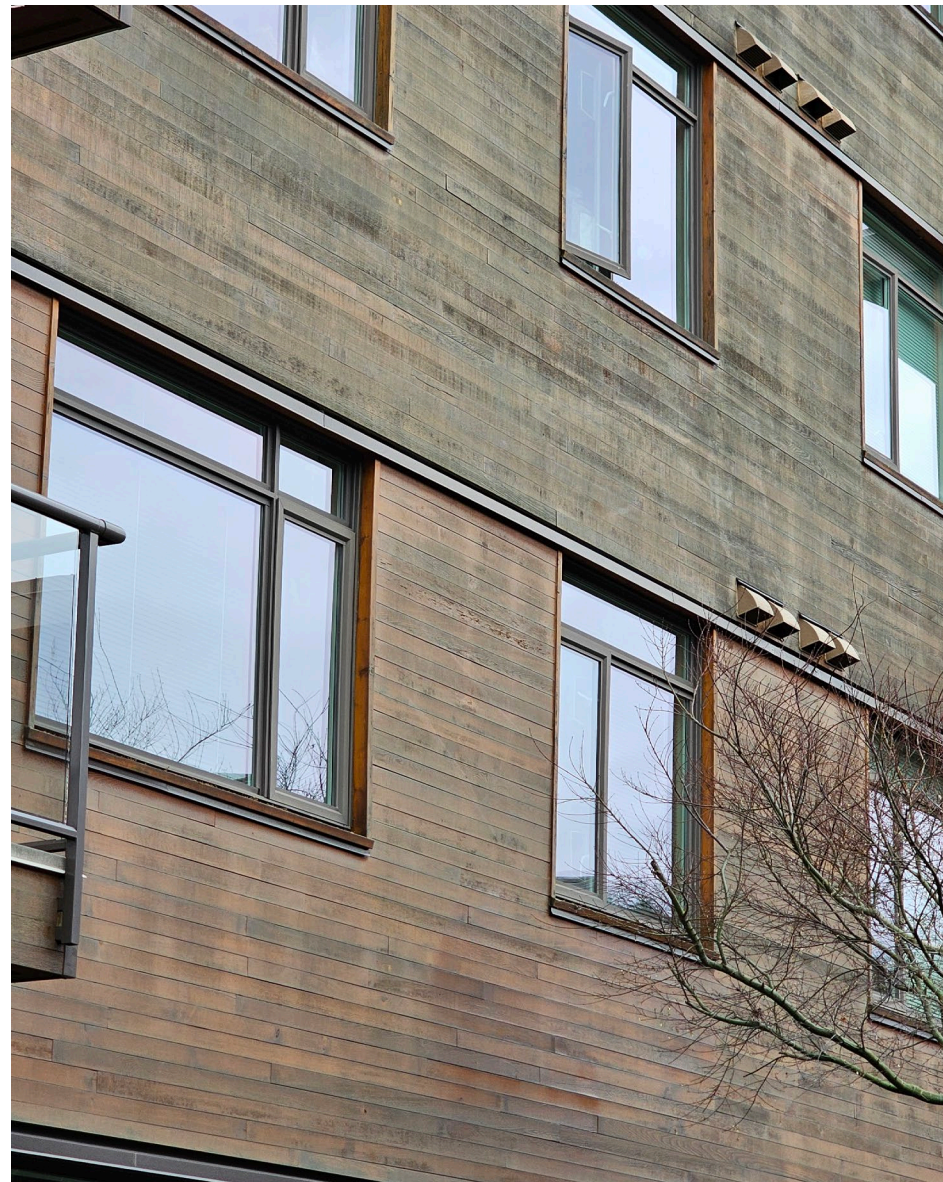
Full 360° Spectrum of Weathering...



A Fortunate Reality?



Wood Cladding Maintenance Is a Lot of Work



What Have We Been Told for Finish Life?

General Technical Report FPL–GTR–282

Table 16–2. Suitability and expected service life of finishes for exterior wood surfaces^a

Type of exterior wood surface	Tinted finishes such as deck finishes		Semitransparent stain		Paint and solid-color stain		
	Suit-ability	Expected service life ^b (years)	Suit-ability	Expected service life ^c (years)	Expected service life ^d (years)		
					Suit-ability	Paint	Solid-color stain
Siding							
Cedar and redwood							
Smooth (vertical grain)	Low	1–2	Moderate	2–4	High	10–15	8–12
Smooth (flat grain)	Low	1–2	Moderate	2–4	Moderate	8–12	6–10
Saw-textured	High	2–3	High	4–8	Excellent	15–20	10–15
Pine, fir, spruce							
Smooth (flat grain)	Low	1–2	Low	2–3	Moderate	6–10	6–8
Saw-textured (flat grain)	High	2–3	High	4–7	Moderate	8–12	8–10

^aEstimates were compiled from observations of many researchers. Expected life predictions are for average location in the contiguous USA; expected life depends on climate and exposure.

^bThe higher the pigment concentration, the longer the service life. Mildew growth on surface usually indicates the need for refinishing.

But What About?

- Other Wood Species Being Promoted in Current Market
- Less Durable Softwood Cladding
- Hardwoods as Cladding
- Modified Bamboos
- Thermally Modified Softwoods & Hardwoods
- Chemically Modified Softwoods
- Fire Treatment Impregnated Softwoods

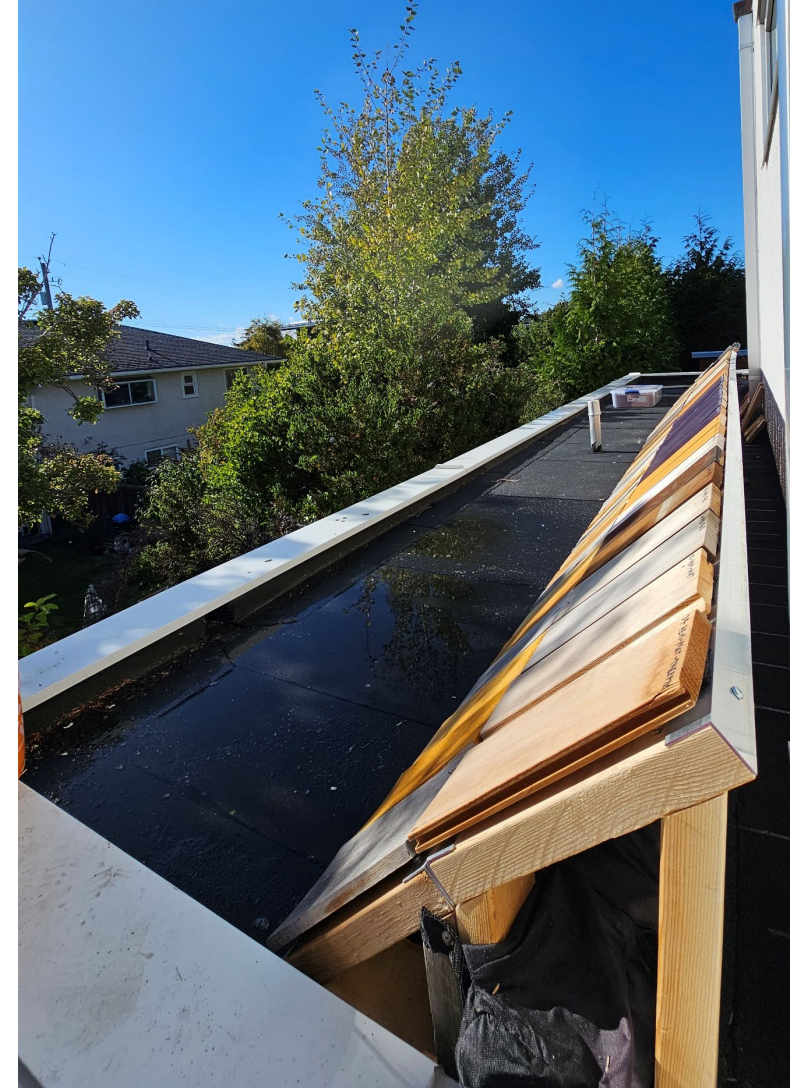
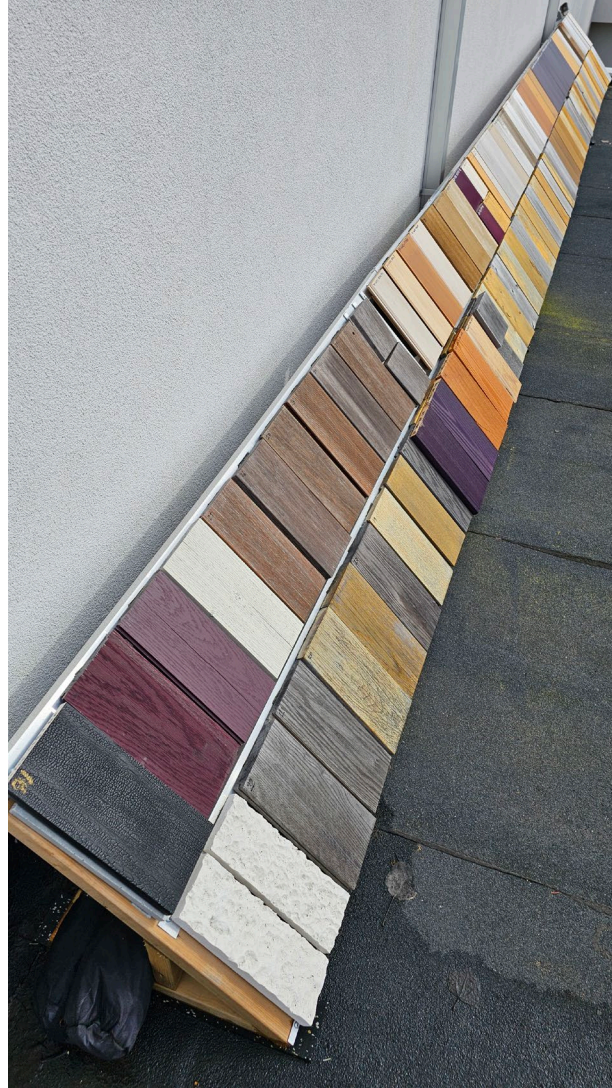
- New More Environmentally Friendly Stains & Finishes?

Typical Architectural Design Question: What is the Service Life For These Samples?



Goal: Accelerated Field Exposure Testing

- 12" long x ~6" wide wood cladding samples for weathering. Plus un-weathered control sample
- 45 degree slope facing south
- Intentionally challenging to accelerate longer-term weathering effects. Use select vertical controls with less exposure to calibrate observations
- At documentation times under similar light/cladding dampness)
 - Photos w/ controls
 - Microscopic photos of surface
 - Observations of fungal growth, finish deterioration
 - Spectrophotometer to numerically quantify color shifts
 - Wetting angle (on flat)



Current Woods, Grain and Stain/Finish/Finishes

WOODS	
Term	Definition
<u>AYC</u>	Alaskan Yellow Cedar
<u>WRC</u>	Western Red Cedar
<u>ACC</u>	Acetylated Pine
<u>TEAK</u>	Plantation Teak
<u>FIR</u>	Douglas Fir
<u>HEM</u>	Hemlock
<u>PIN</u>	Pine
<u>W.OAK</u>	White Oak
<u>R.OAK</u>	Red Oak
<u>TMO</u>	Thermally Modified Red Oak
<u>MMB</u>	Mineral Modified Bamboo
<u>TMB</u>	Thermally Modified Bamboo
<u>KEB</u>	Furfurylated Pine
<u>TM-HEM-FT</u>	Hemlock, Thermally Modified & Fire Treated
<u>TM-HEM</u>	Hemlock, Thermally Modified (x2 suppliers)
<u>FIR CHX</u>	Douglas Fir, Fire Treated
<u>WRC CHX</u>	Western Red Cedar, Fire Treated

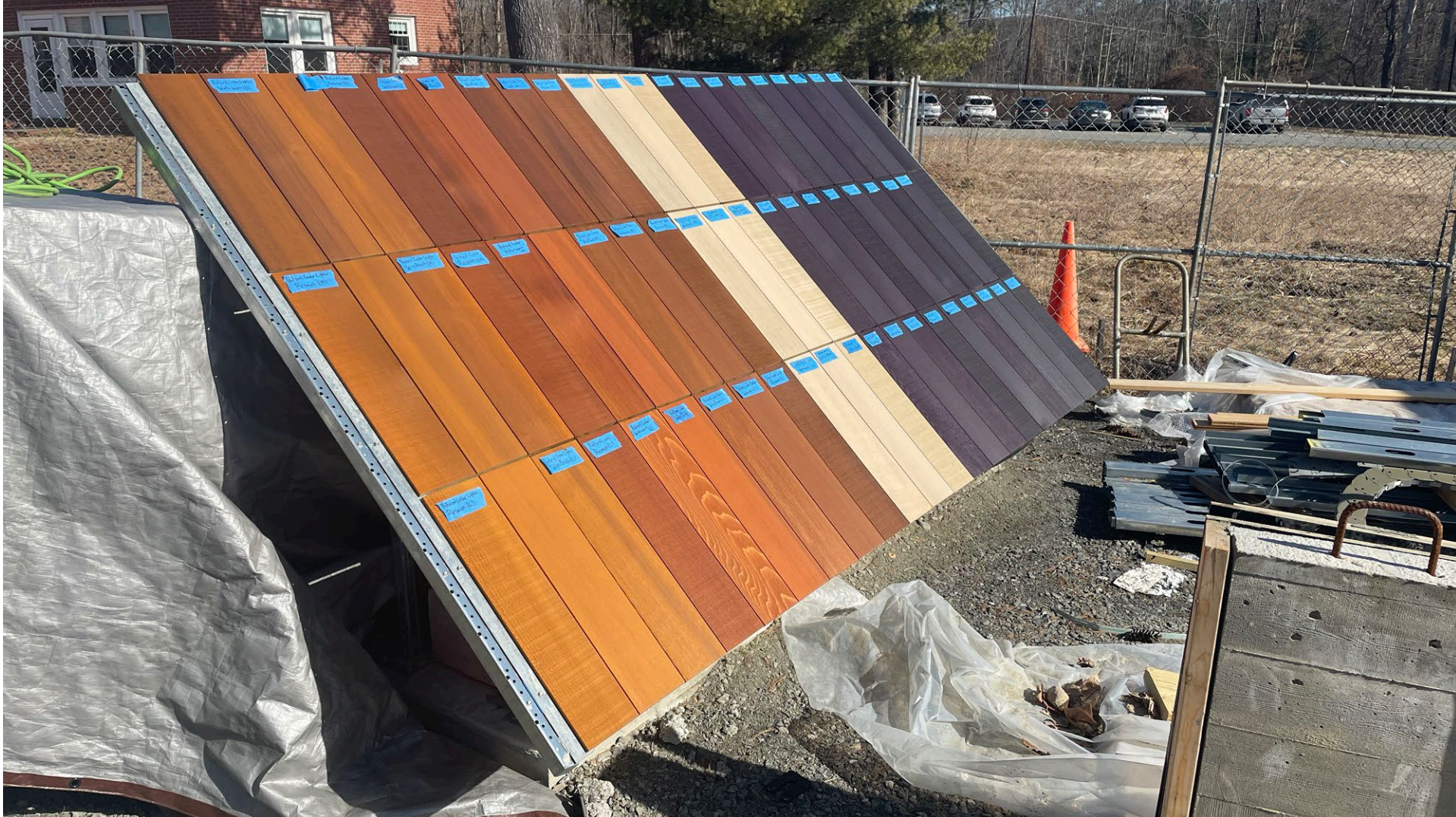
STAINS/TREATMENT	
Term	Definition
FeS	Ferrous Sulphate
FeA	Ferrous Acetate
FeAl	Ferrous Aluminum
SDF	Penetrating Stain 1
ENS P	Film Forming Stain 1
RES2 - G	High Build Film Forming Stain 2
SiOOX	Silicon/Potassium based stain
SO	Nano Penetrating Stain 2
TPUV	Film Forming Stain 2
BR1	Penetrating Stain 3
BR2	Film Forming Stain 2
SSB	Shou Sugi Ban
None	None, Natural

GRAIN VARIATIONS	
Term	Definition
MG	Mixed Grain
VG	Vertical Grain
STK	Select Tight Knot

Additional Weathering Testing – Onsite for Project



Additional Accelerated Weathering Testing – Onsite for a Project



Weathering Documentation, Initial & 13 Months



Initial Sample Setup, Un-weathered. Western Red Cedar (WRC) hence 03-WRC naming that is field finished with film forming stain 1 (left), penetrating stain 1 (middle), and unfinished (right). The control sample (lower right) is cut from same cladding pieces and its color and grain to represent the unfinished sample here



Example documentation at point in time (dated and is ongoing). Photo is showing the same three weathered samples vs control as in photo to the left from initial setup. Additional observations such as wood distortion, checking/splitting, fungal growth, finish deterioration etc are commented on as observed. Microscopic photos and spectrophotometer observations also taken at intervals

3 Years on Exposed Wall vs ~1 Year Accelerated Weathering



Western Red Cedar (WRC) – Microscopic Review

03-WRC: Smooth Finish, **Vertical Grain**. 3 Samples: *Film Forming Stain 1, Penetrating Stain 1, Unfinished*

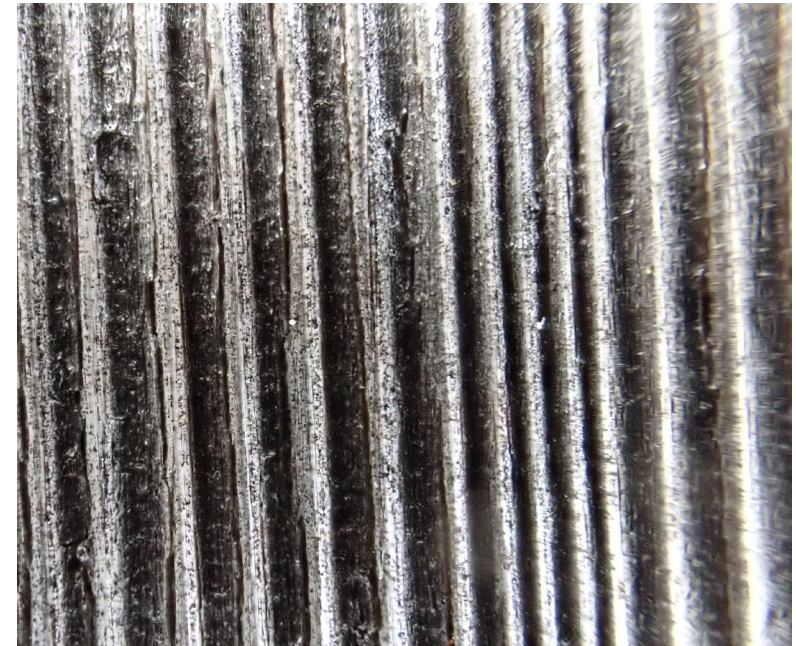
Samples after 16 months of Weathering



Film Forming Stain –
Staining Fungi Underneath Stain in Wood
Coating Still Hydrophobic



Penetrating Stain –
Some surface fungi growth
Note different stain penetration (with some residual on surface) between late and early wood grain
Coating no longer hydrophobic



Unfinished –
Some raising of grain

Western Red Cedar (WRC) – Microscopic Review

03-WRC: Smooth Finish, **Flat Grain**. 3 Samples: *Film Forming Stain 1, Penetrating Stain 1, Unfinished*

Samples after 16 months of Weathering



Film Forming Stain –
Staining Fungi Underneath Stain in Wood
Coating Still Hydrophobic



Penetrating Stain –
Some surface fungi growth
Note different stain penetration (with some residual on surface) between late and early wood grain
Coating no longer hydrophobic
Some raising of grain

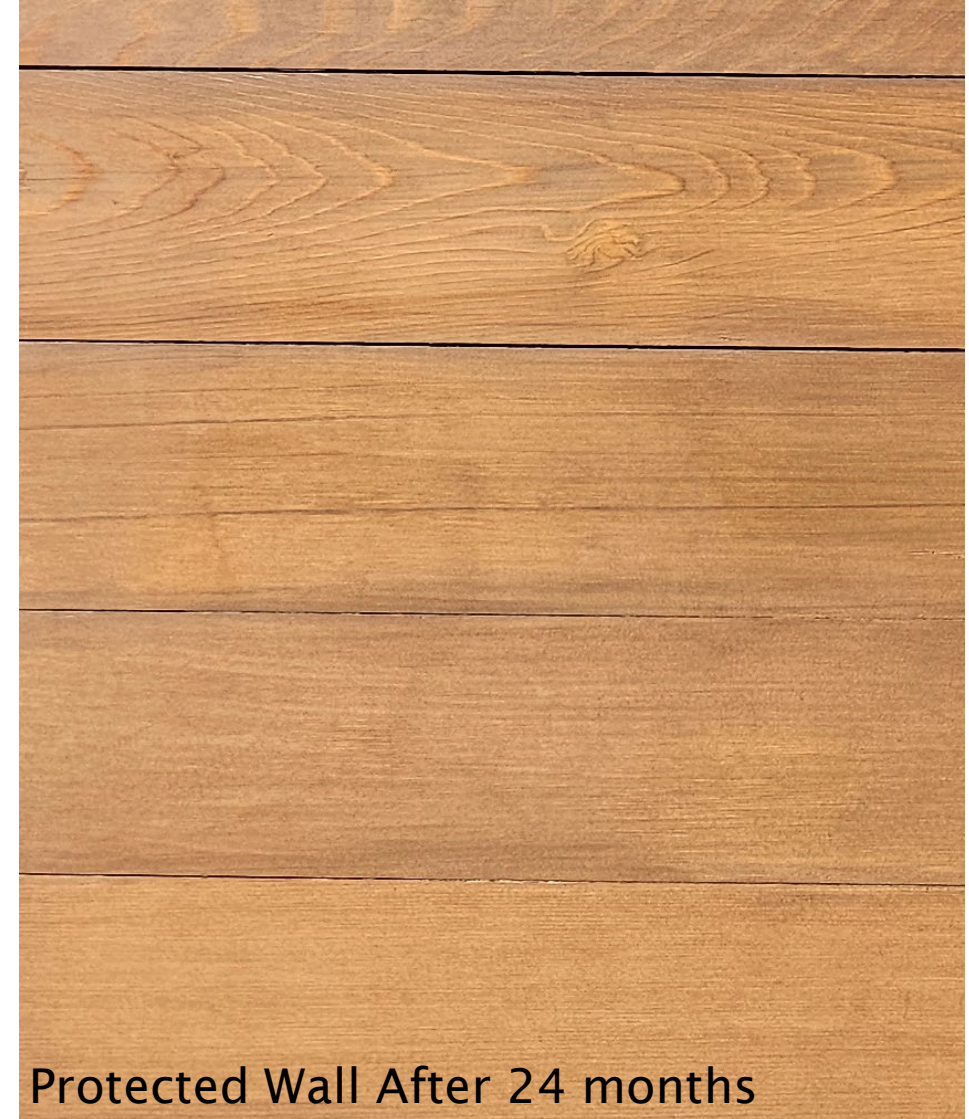


Unfinished –
Some raising of grain

Quantification & Documenting Color Changes?

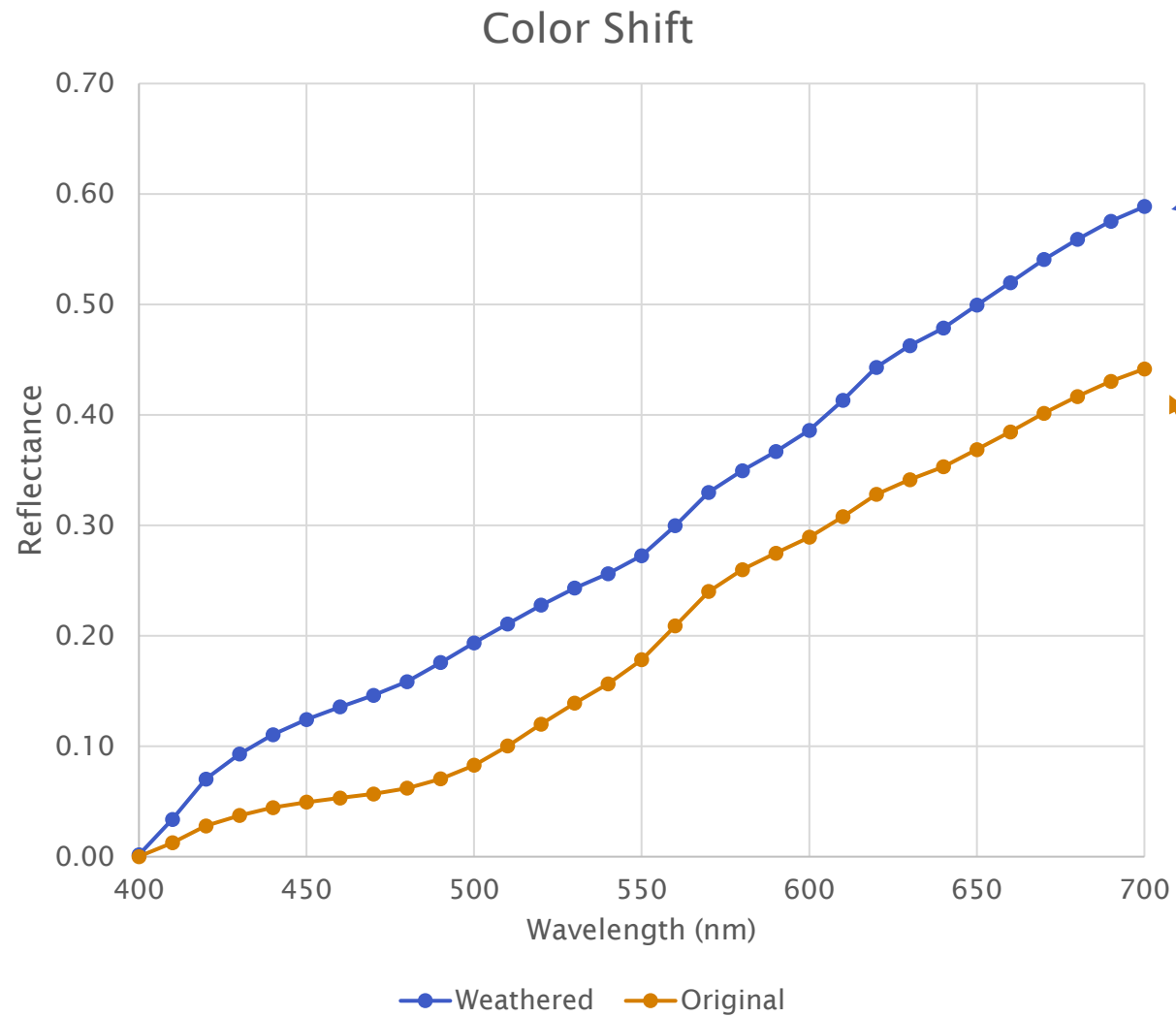
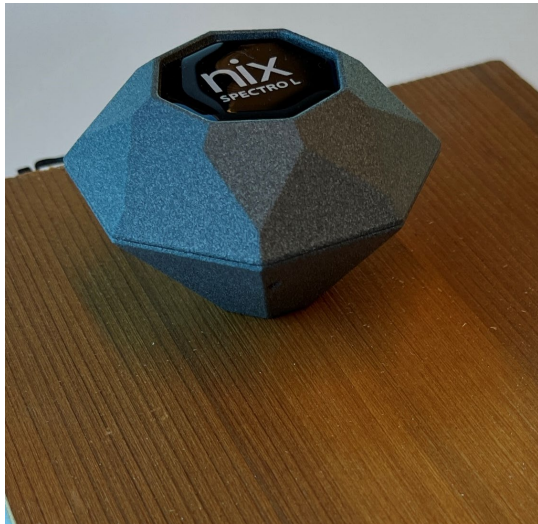


Exposed Samples After 13 months



Protected Wall After 24 months

Spectrophotometer to Quantify Color Shift



Weathered Sample



ΔE (CIE2000): 9.55



Original Sample

Same Species, Different Grain and Finish Comparisons

Western Red Cedar (WRC) Samples after 13 months of Weathering



*03-WRC – Smooth Finish
Vertical Grain
Film-forming stain 1,
penetrating stain 1,
Unfinished*



*04-WRC – Smooth Finish
Flat Grain
Film-forming stain 1,
penetrating stain 1,
Unfinished*



*05-WRC – Rough Finish &
Vertical Grain
Film-forming stain 1,
penetrating stain 1,
Unfinished*

Different Species, Same Grain and Finish Comparisons

Samples after 13 months of Weathering

Douglas Fir



*13-FIR – Smooth Finish Vertical Grain
Film-forming stain 1, penetrating
stain 1, Unfinished*

Hemlock Fir



*14-HEM – Smooth Finish Vertical Grain
Film-forming stain 1, penetrating stain
1, Unfinished*

Ponderosa Pine



*15-PIN – Smooth Finish Vertical Grain
Film-forming stain 1, penetrating
stain 1, Unfinished*

Smooth Sanded vs Rough Sawn Alaskan Yellow Cedar

13 Months Weathering



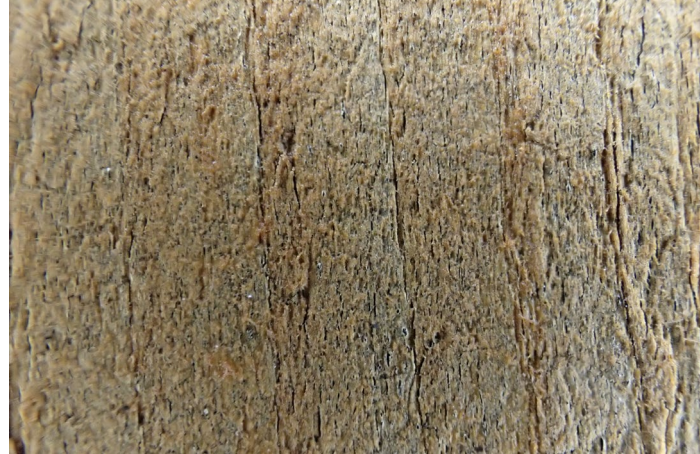
Smooth Sanded vs Rough Sawn Alaskan Yellow Cedar

16 Months of Weathering

Smooth/Sanded



Film forming

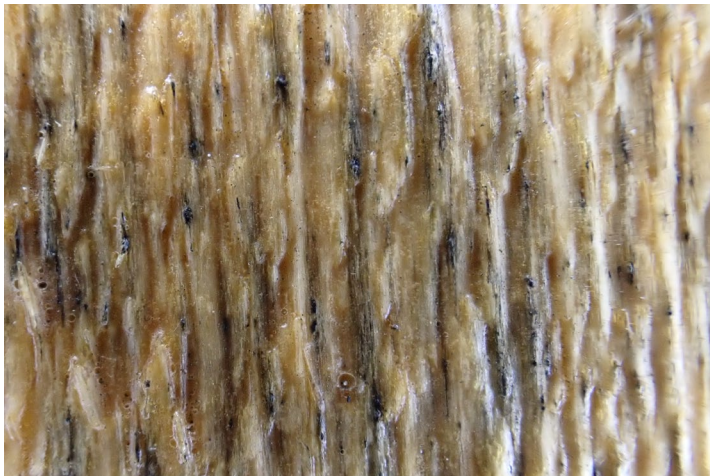


Penetrating



Unfinished

Rough Sawn



Observing Seasonal Weathering Patterns (Hemlock)

13 & 16 months (dry vs wet)



Observing Weathering Patterns (Hemlock)

After 16 months, Microscopic



Film forming



Penetrating



Unfinished



Observing Weathering Patterns – Thermally Modified Red Oak

13 Months (Film Forming, Penetrating, Unfinished)

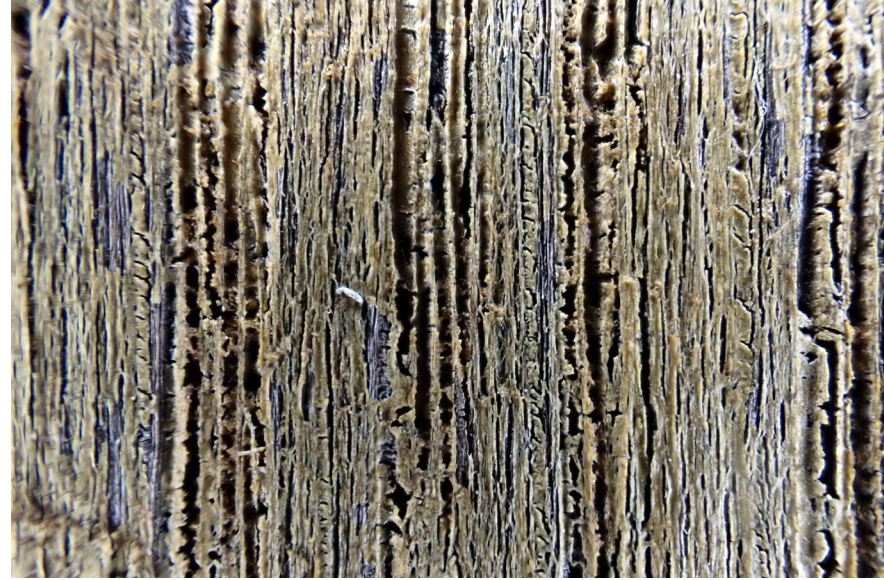


Observing Weathering Patterns (TM Red Oak)

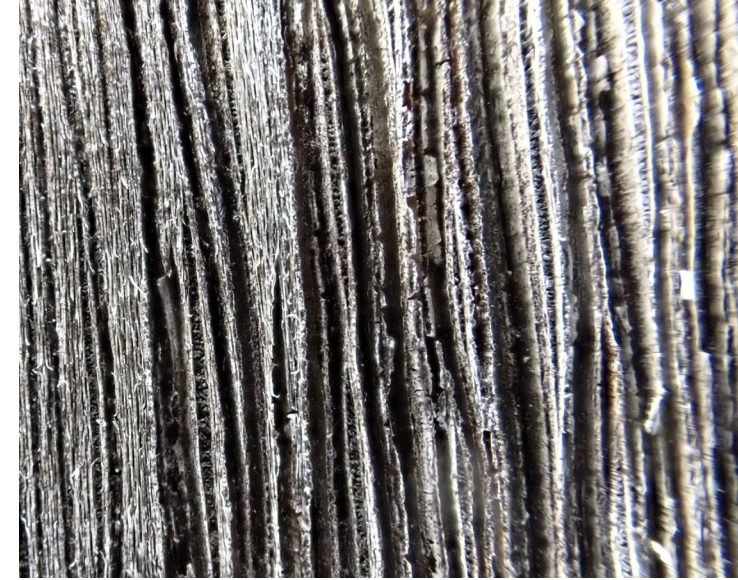
After 16 months, Microscopic



Film forming



Penetrating

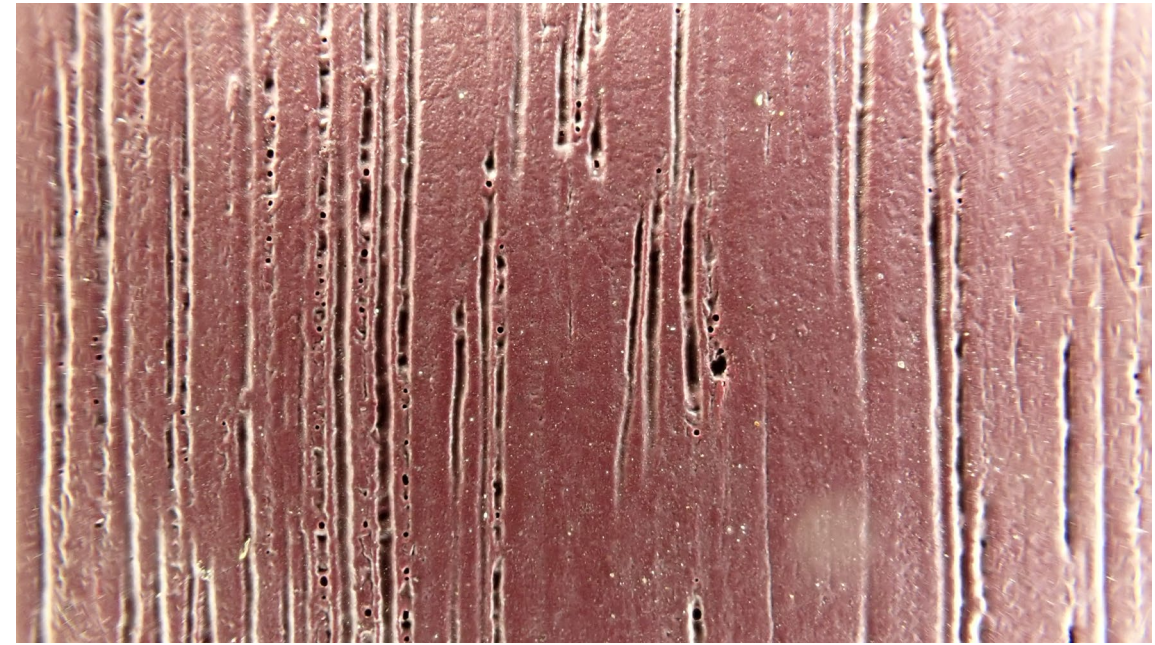


Unfinished



Finish Observations

16 Months Film Forming vs Penetrating
over Thermally Modified Oak



Factory Pre-finished vs Site Finished

Same Penetrating Stain (Minor Shade Differences)



Natural Weathering Color Shifts & Ugly Years



Key Conclusions to Date

- Accelerated weathering setup can provide useful visual results in 6-12 months to supplement local weathering experience on buildings (where available)
 - Can assess different wood species and grain/grading options during the usual design process timeline (SD-DD-CD)
 - Useful to relatively compare performance of different stain types and see failure mechanisms to estimate maintenance requirements
 - Proceed with caution when selecting new modified woods, alternate species etc.
- Clear/lightly pigmented stains still unfortunately only appear to last between 1-3 years in exposed and wetted applications. Experience has shown longer when exposed to very minimal wetting and overhead applications like soffits
 - Factory applied finishes appear to last longer than site applied
 - Dark stains (because of UV pigments) show obvious improvements
- Modified woods weather differently, still susceptible to fungal growth, stain lifespan and performance varies



**MANAGING AESTHETIC EXPECTATIONS FROM WEATHERING OF WOOD CLADDINGS
WITH CLEAR FINISHES**

Questions and Discussion

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Thank You

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