Shou Sugi Ban

Exploring the characteristics and aesthetics of charred wood as a cladding material

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January 19, 2017

Source - http://resawntimberco.com/charred-wood-shou-sugi-ban-video/

Introduction

- About us:
  - Recent graduates of the Architectural and Building Technology program at BCIT
  - 1st place winners of the BCIT Capstone Research Project judged by the BC Building Envelope Council – Topic: Shou Sugi Ban
  - Now employees of Morrison Hershfield, RDH Building Science, and BC Building Science

What We'll Cover Today

- A brief history of Shou Sugi Ban – origin and applications
- Charring techniques - traditional and modern
- Technical basics – the science of charred wood
- Our research at BCIT – accelerated weathering, flame spread testing
- Discussion

Shou Sugi Ban

- Shou Sugi Ban (aka: Yakisugi) “Burnt Cedar Board”
- Process of charring the surface of wood to improve it’s longevity
- Claimed to increase resistance to fire, rot, and insects
- Looks amazing but comes with some challenges

A Brief History

- Believed to date back to the 1700's in Japan
- Used for centuries, experiencing greater attention in North America
- Claimed to last up to 80 years – but this is subjective
- Traditional species is Cryptomeria Japonica (aka Japanese Red Cedar)

Source - Wikimedia Commons - Paul Venter - Own work, CC BY-SA 3.0,

A Brief History

- Today, many species are used depending on local climate and application (Western Red Cedar, Douglas Fir, Oak, Pine, Hickory, Chestnut, Cypress)
- In Japan, charring wood is seen as more of a ‘utility’ siding
- In North America, it’s a premium ‘designer’ product

Source – http://www.woodnolimits.com/single-post/2016/02/14/Shou-Sugi-Ban-the-Japanese-technique-of-wood-charring

What it looks like

Lamune Onsen, Japan, Terunobu Fujimori Architect

Photo: Adam Friedberg, Source: http://www.thewellappointedcatwalk.com/2013/03/the-architecture-of-terunobu-fujimori.html

Guest House, Japan, Terunobu Fujimori Architect

Photo: Adam Friedberg, Source: http://www.thewellappointedcatwalk.com/2013/03/the-architecture-of-terunobu-fujimori.html

What it looks like

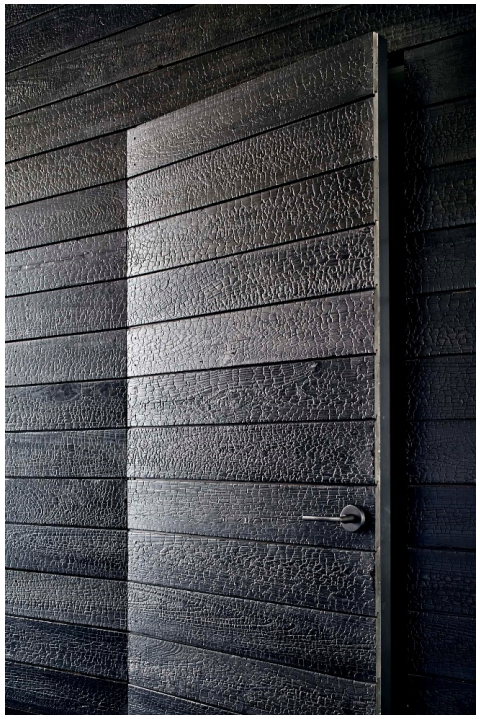
Evergreen House, North Vancouver, Michael Green Architects

Source - http://mg-architecture.ca/work/evergreen-residence/

Worthy Ken House, UK, Chris Dyson Architects

Photo by Peter Landers, Source http://www.chrisdyson.co.uk/Projects/Worthy-Ken-House

What it looks like



Prefab House, Texas, Aamodt / Plumb Architects

Source - http://deltamillworks.com/portfolio/modern-texas-prefab-austin-tx

What it looks like

Sands Point Home, Long Island, CDR Studio Architects

Source - http://www.cdrstudio.com/work/residential/sandspoint

Rocksalt Restaurant, UK, Guy Holloway Architects

Source - http://www.guyhollaway.co.uk/architecture/rocksalt/

What it looks like

Wood Innovation and Design Centre, Prince George, Michael Green Architects

Source - http://mg-architecture.ca/work/wood-innovation-design-center/

What it looks like

Kalamalka Lake Home, Vernon, BLDG Workshop

Source - http://bldgworkshop.ca/projects/kalamalka-lake-home/

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Kalamalka Lake Home, Vernon, BLDG Workshop

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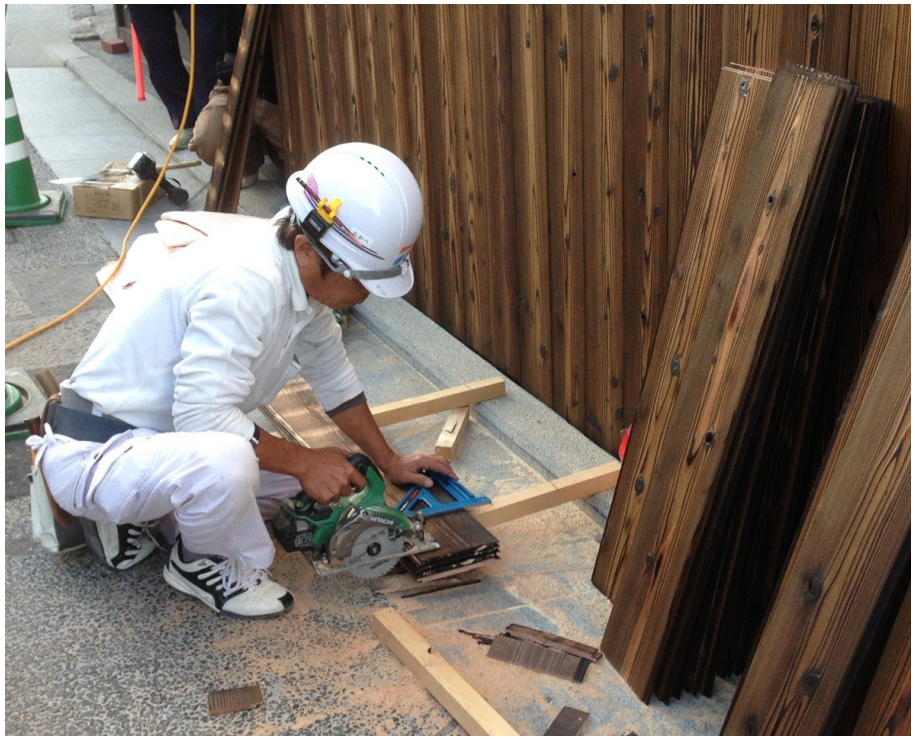
What it looks like

- Installations in Japan

Source: Nakamoto Forestry

What it looks like

- Installations in Japan



Source: Nakamoto Forestry

How it’s made – The traditional method

Source: http://mag.sanson.asia/kominka_saisei_07/

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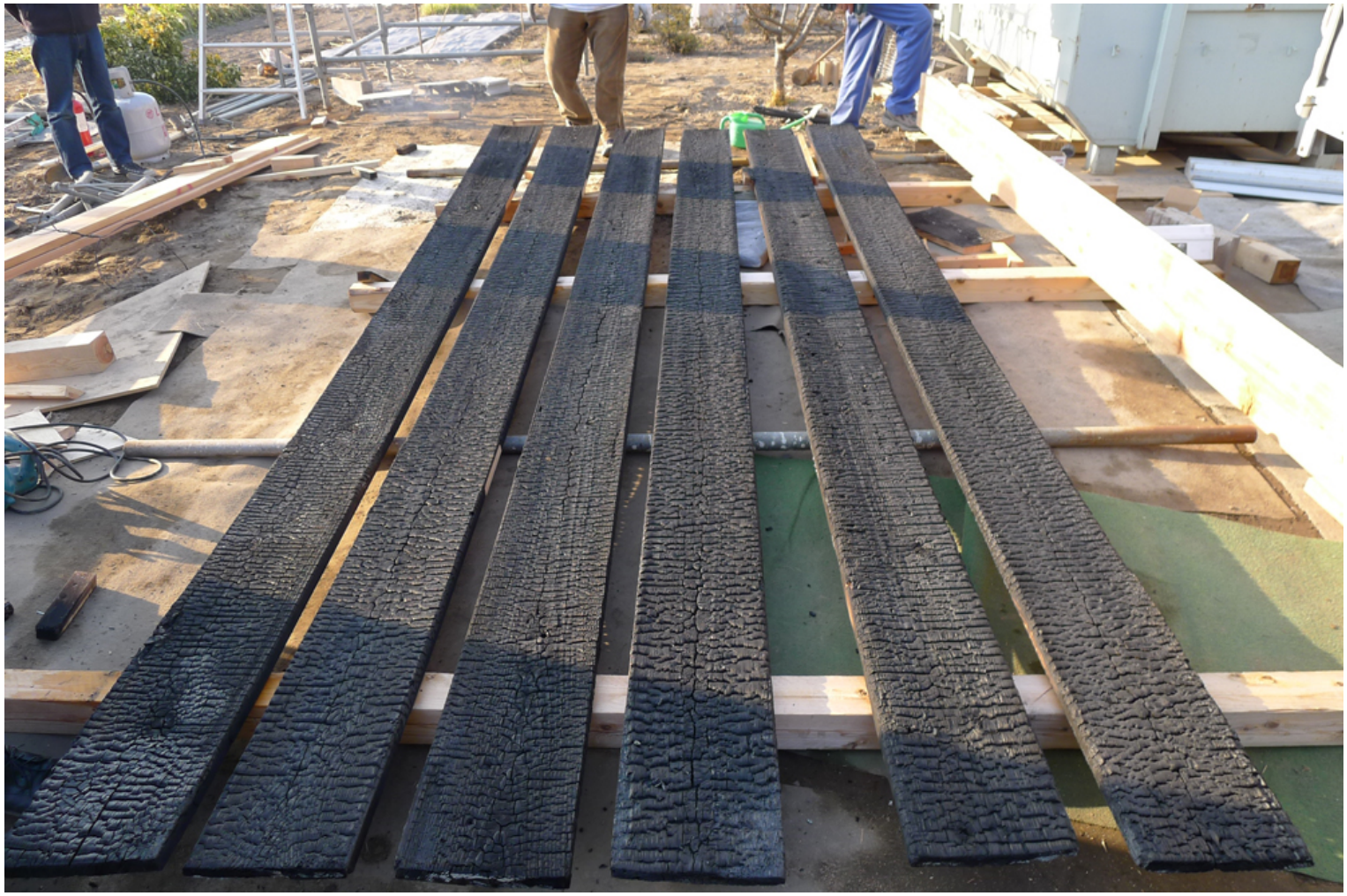


Source: http://mag.sanson.asia/kominka_saisei_07/

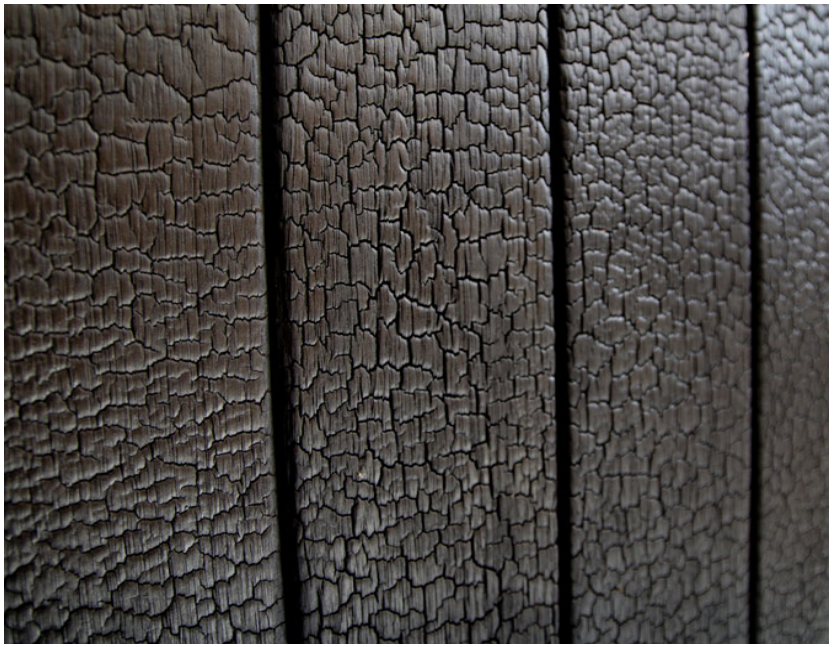
How it’s made – Modern methods

How it’s made – Modern methods

Source: www.deltamillworks.com/shou-sugi-ban

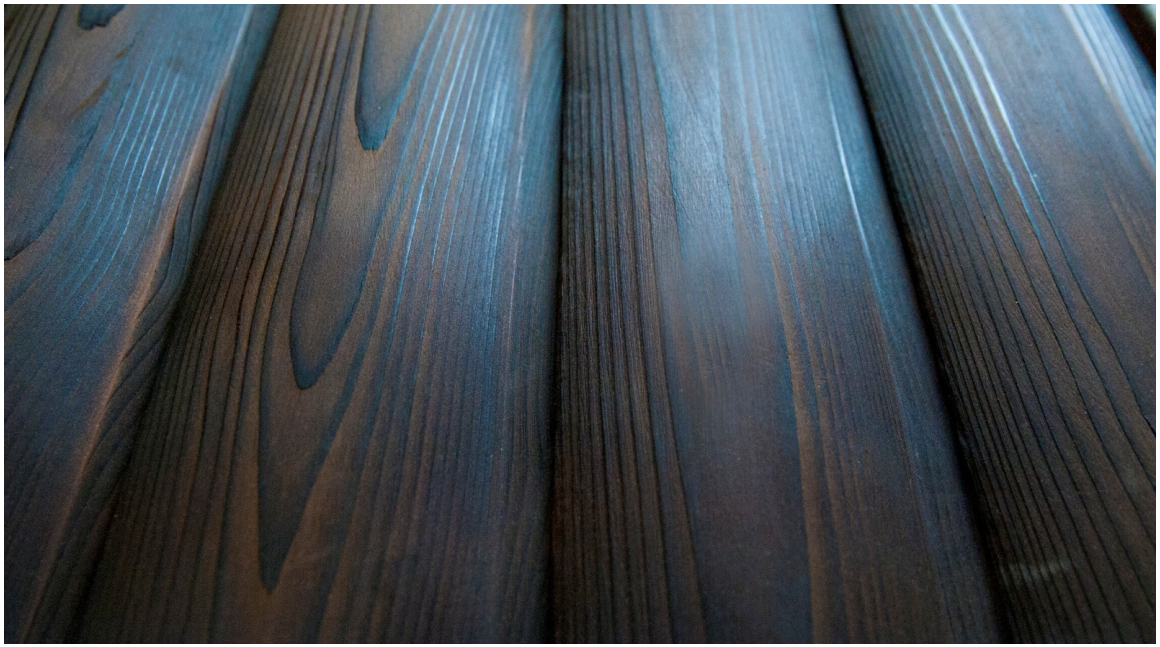
Surface appearances

Deep Char



Source: www.deltamillworks.com/exterior-siding-paneling

Brushed and finished



Source: www.Kindl.ca

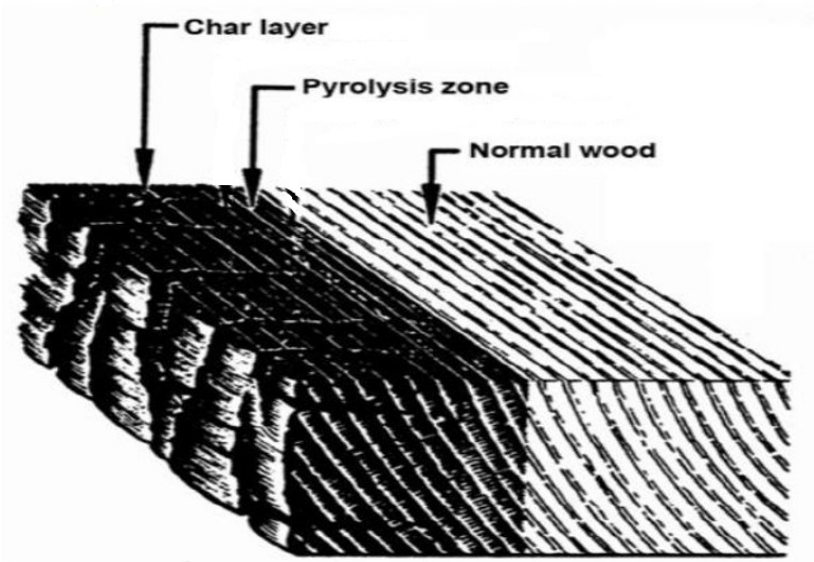
Wood Structure

- 3 main components of wood – cellulose, hemicellulose and lignin;
  - 1st element to break down when burned – hemicellulose (23-30%)
  - 2nd – cellulose (41-45%), highest combustion
  - 3rd – lignin (19-33%), slower to burn, glowing ember
- Burning results in volatile gases, tar, and carbonaceous char

Source: Lowden, L. A., & Hull, T. R. (2013). Flammability behavior of wood and a review of the methods for its reduction.

When wood is charred

- Pyrolysis
  - Degradation process due to extreme temperatures. This is the leading edge of the charring process.
  - Increased resistance to further charring protecting the structural integrity of the lumber.
  - As char depth increases the insulating affect increases and slows the rate of char.



Source: Forest Products Laboratory. (2010). Wood handbook; wood as an engineering material.

Acetylated Wood

- An increasing portion of charred wood products manufactured in North America are using acetylated wood
- Benefits:
  - Significantly reduced water absorption
  - More dimensionally stable
  - More durable
  - Accepts char well

Acetylated Wood

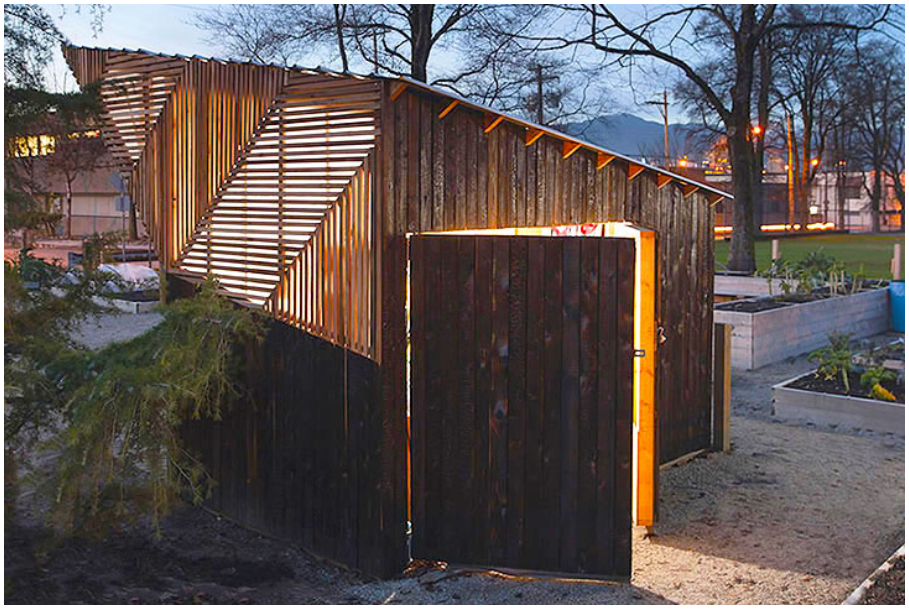
- Acetylation – The process of modifying the wood at a molecular level within the lignin and hemicellulose.
- Acetic anhydride is used to change the hydroxyl groups present in wood into acetyl groups – the wood molecules will not bond well with water molecules.

Fungi and Insects

- Burning the wood reduces food source and moisture available for fungi growth to propagate
- Lignin slower to burn, harder structure, more difficult for insects to consume
- No in-depth research discovered on insects and charred wood has been found

Weathering

- Woodland Park Garden Shed, Vancouver (2013)



South-West Elevation

North-East Elevation

Architects: Brendan Callander, Jason Pielak and Stella Cheung-Boyland

Source: http://ca.archello.com/en/project/woodlands-community-garden-shed

Weathering

- Woodland Park Garden Shed, Vancouver (2013)

East Elevation

Close-up

Source: http://ca.archello.com/en/project/woodlands-community-garden-shed

Weathering

- Woodland Park Garden Shed, Vancouver (2016)

South-East Elevation

South-West Elevation

Weathering

- Woodland Park Garden Shed, Vancouver (2016)

East Elevation

Close-up

Weathering

- Installations in Japan

Source: Nakamoto Forestry

Weathering

- Installations in Japan

Source: Nakamoto Forestry

Preserving the look

- Many finishes are used to preserve the look, such as:
  - Film forming finishes
  - Penetrating stains
  - Oils
  - Heavy polymers
  - Epoxies
- Maintenance and reapplication of the finish will be required to prolong the lifespan, like any wood finish – can be more difficult with a charred surface

BCIT Research Project:

- Topic chosen by the students
  - Related to building science
  - What the industry may want to know

- Limitations
  - Time: deadlines, exams, and a full course load
  - Funding: working on a student budget

BCIT Research Project:

- So we decided to focus on these questions
  - Does wood density influence longevity of char?
  - Can standard wood finishes help to preserve the char?
  - How much does the charring affect surface reignition?

- Our methods:
  - Accelerated weather testing at FP Innovations Laboratory, Vancouver
  - Flame Spread testing at Intertek, Coquitlam

Accelerated Weather Testing

- Sample Preparation:
  - Created 80 samples with the different combinations of char depth, species, and finish
  - Light surface char and deeper 1.5mm char (roofing torch method)
  - Western Red Cedar and Douglas Fir

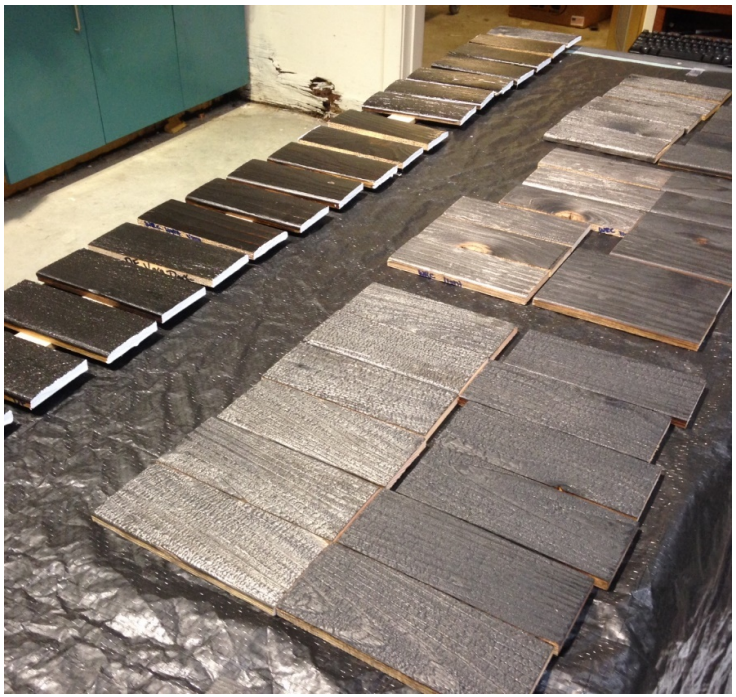
Accelerated Weather Testing

- Sample Preparation:
  - Coated with a film forming finish or penetrating stain
  - Cut to size: 160 x 65 x 10mm
  - Cut ends sealed with epoxy to represent a longer board size

Accelerated Weather Testing

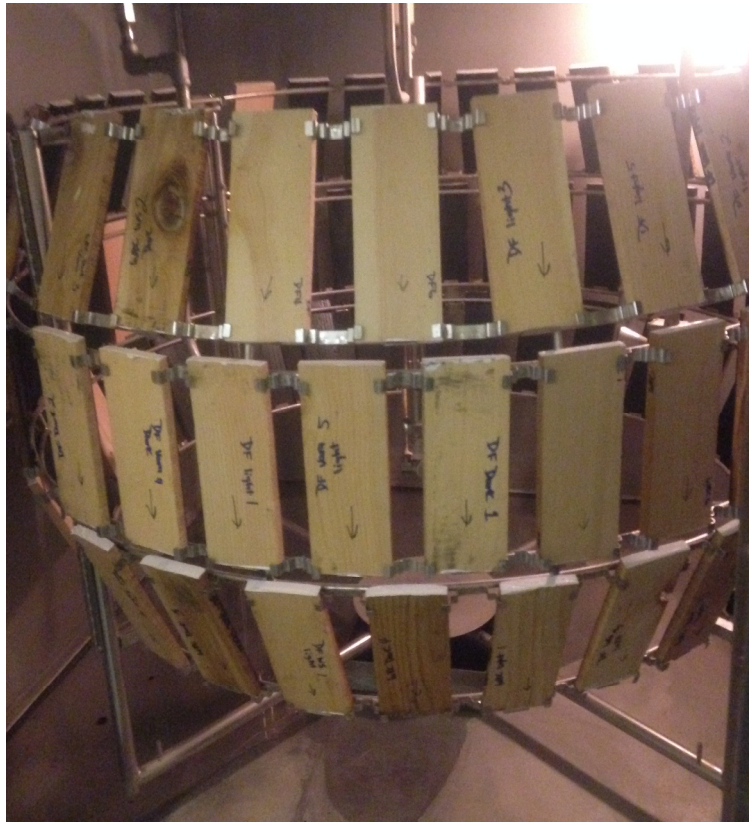
Variation	Species	Depth of Char	Finish
1	Western Red Cedar	None	None
2	Western Red Cedar	Light	Film Forming Finish
3	Western Red Cedar	Dark	Film Forming Finish
4	Western Red Cedar	Light	Penetrating Stain
5	Western Red Cedar	Dark	Penetrating Stain
6	Douglas Fir	None	None
7	Douglas Fir	Light	Film Forming Finish
8	Douglas Fir	Dark	Film Forming Finish
9	Douglas Fir	Light	Penetrating Stain
10	Douglas Fir	Dark	Penetrating Stain

Accelerated Weather Testing



Accelerated Weather Testing – Weather-ometer

- Reproduces and accelerates the aging process
- Single xenon arc lamp provides high intensity UV radiation
- Chamber produces high humidity and direct spray on surfaces



Accelerated Weather Testing – Weather-ometer

Test conditions consist of repeating cycles of:

- 102 minutes of light exposure
- 18 minutes of darkness with water spray
- Produced air temperature readings of 40°C during light exposure and 24°C when dark
- Total test duration of 600 hours – constant rotation within chamber
- Based on FP Innovations experience with weather testing wood samples

Accelerated Weather Testing - Results

- Douglas Fir - Deep Char

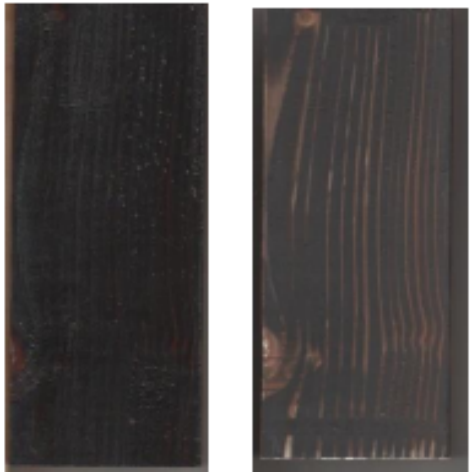
Bare Wood | No finish | Penetrating Stain | Film Forming

Accelerated Weather Testing - Results

- Douglas Fir - Light Char

No Finish

Penetrating Stain



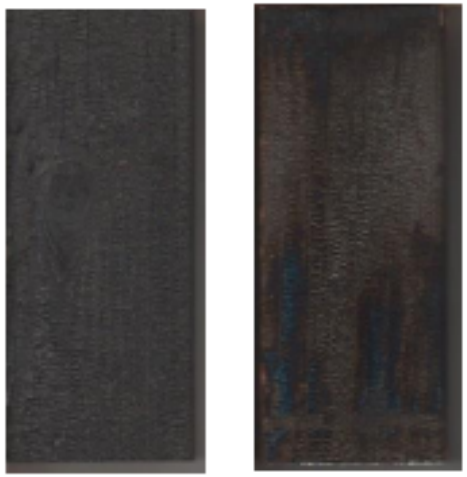
Film Forming

Accelerated Weather Testing - Results

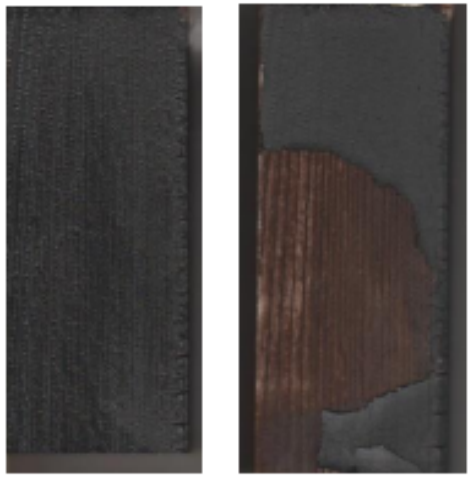
- Western Red Cedar - Deep Char

Bare Wood

No Finish



Penetrating Stain



Film Forming

Accelerated Weather Testing - Results

- Western Red Cedar - Light Char

No Finish

Penetrating Stain

Film Forming

Accelerated Weather Testing - Outcome

- Depth or char directly correlates to lifespan of char
- Char outlasts finishes applied
- The deeper the char the longer it lasts regardless of finish
- Lifespan depends on personal opinion and preferred look – highly subjective
- Finishes we used had almost no effect on preserving the char.

Flame Spread Testing – Steiner Tunnel

- ASTM E84: Standard test method for surface burning characteristics of building materials
- 24’ sample is placed into the tunnel
- Visual observation used to mark flame spread progression through length of tunnel over time
- An optical sensor measures smoke density

Flame Spread Testing – Steiner Tunnel

A1

Flame Spread Testing - Results

Flame Spread Index (FSI) scale: Asbestos cement board = 0, Red Oak = 100

- Western Red Cedar, bare wood: 73
- Required for non-combustible construction: 25
- Flame Spread Index of charred sample: 15
  - Note: This number will likely increase over time as the char thickness diminishes

Source: Fire Safety in Buildings, 1995

A1

Flame Spread Testing - Results

Smoke Developed Index (SDI) scale: Same as FSI

- Western Red Cedar, bare wood: 98
- Smoke Developed Index of charred sample: 5

Source: Fire Safety in Buildings, 1995

Recap

- A unique material to create visual contrast
- Many variables to consider – species, char depths, finishes
- Like all wood, it will age over time

Westport Residence, Connecticut, Vita Design Group

Source www.accoya.com/projects/project/charred-accoya-selected-for-private-residence-in-bellport-new-york/

Special thanks to:

- BCBEC- 1st place award and hosting today
- Rod Stirling, PhD – FP Innovations
- Graham Finch, Dipl. T, MASc, P.Eng – RDH Building Science
- Greg Philp – Intertek Testing Services
- Ron Krpan, P.Eng – BCIT

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Intertek

RDH

Thank You!