

BIOGENIC MATERIALS FOR MASS TIMBER WALL ASSEMBLIES



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Terminal Project*

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ABSTRACT:

This Terminal Project investigates the potential of biogenic materials sourced from living organisms in the Pacific Northwest to enhance the sustainability of mass timber wall assemblies, specifically focusing on the insulation, the weather resistant barrier and the cladding materials. By developing a replicable model, I aim to extend its applicability to other mass timber production regions such as Australia/New Zealand and Japan. While it is recognized that mass timber sequesters carbon, many non-biogenic insulation and cladding products have been critiqued for their carbon impacts in their production, application, and lifespan (Abed, Joseph, et al, 2022). The study recognizes the carbon impacts of conventional non-biogenic insulation and cladding products, aiming to promote sustainable construction practices by exploring regionally available and novel biogenic materials, including those derived from older practices, waste products and invasive species. In the background research I explore what biobased materials are already implemented within the aforementioned regions and created a catalog of their properties and current uses.

The project involves collaboration with the Material Composites Lab at Oregon State University to develop oriented-strand board cladding from wood fiber of invasive species like Western Juniper, a bioplastic weather-resistant barrier, and thermal/ acoustic insulation using agricultural wastes bound with mycelium. Insulation specimens include blue oyster mushrooms (Pleurotus ostreatus) and reishi mushrooms (Ganoderma lingzhi). Testing evaluated the thermal and acoustic properties of these mycelium panels as compared to commercially available bio-based materials. Testing was performed on sample mass timber wall assembly mockups in the small acoustic testing chamber at the Energy Studies in Building Laboratory in Portland and in a fabricated thermal hotbox I made using ASTM standards to guide the construction.

The assemblies, made from a 32"x 32", 3-ply cross laminated timber (CLT) panel, that was splined together from smaller pieces, for replication of typical CLT panel connections incorporated the biogenic products outboard of the material to gather data on their viability as competitors for already commercialised biogenic materials, namely STEICO flex at 2"(50mm) wood fibre insulation.

The goal is to develop a sustainable model that addresses regional challenges posed by invasive species, promotes the use of locally sourced bio-based materials, and revives traditional building practices, thereby advancing material autonomy and sustainable practices in the construction industry.

DEFINITION

Material Autonomy

Definition:

refers to the practice of achieving self-sufficiency and sustainability in the selection, sourcing, making and use of building materials. It emphasizes the use of locally sourced, renewable, and biogenic materials that are derived from living organisms or organic waste products. This concept promotes ecological balance, reduces reliance on non-renewable resources, and minimizes the carbon footprint associated with construction. By integrating traditional practices and modern ecological principles, Material Autonomy aims to foster resilient, sustainable, and environmentally responsible building practices.

Key Components:

Local Sourcing: Utilizing materials that are readily available within the local region to reduce transportation emissions and support regional economies.
Renewable Resources/ Waste Stream Management: Focusing on materials that can be regenerated over time, such as wood, mycelium, and agricultural waste products.
Biogenic Materials: Incorporating materials derived from living organisms, ensuring they are biodegradable or compostable at the end of their lifecycle.
Traditional Practices: Reviving and modernizing age-old sustainable practices to create efficient and culturally relevant construction solutions.
Sustainability: Ensuring that the entire lifecycle of the materials, from production to disposal, has a minimal environmental impact.

MY BACKGROUND

Growing up between India and South Africa I was constantly exposed to vernacular ways of building that were rooted in cultural tradition. This inspired me to connect with the people and listen to the stories that they carried over from their ancestors, especially how they adapted these traditions to modern technologies.

I was always fascinated by the colours and textures that revolved around these practices but what particularly inspired me was the idea of how tactile these materials are. The reality that, if there is a crack in the wall, you were able to simply wet the floor and patch it yourself. People of all ages were able to engage in the process of creating their space by doing and making. Although these practices were imperfect unlike building with steel and concrete, the act of making resulted in communities being empowered as they had material autonomy and were able to connect with the land and their traditions.



THE COW:

The concept of a cradle-to-cradle cycle in many Indian communities is deeply intertwined with the worship and utilization of cows, affectionately known as ‘Gau Mata’ or Mother Cow. This practice is a testament to the profound cultural ethos of minimal waste and sustainability, underscoring the reverence for cows as sacred.

Cows are central to the livelihood of these communities, providing essential dairy products such as milk, butter, ghee, and paneer. These products are not only nutritional staples but also hold significant cultural and religious importance. For instance, ghee is a key ingredient in many rituals and ceremonies, symbolizing purity and prosperity. The daily milking of cows is a practice steeped in tradition, often accompanied by prayers and rituals that honour the cow’s contribution to the family’s well-being.

The process of utilizing cow dung is a brilliant example of transforming waste into valuable resources. Cow dung is collected and meticulously processed with dry grass, straw, clay, and soil to create discs. These cow dung discs are hand-pressed and then dried in the sun for several weeks or months, becoming hard and durable. The preparation of these discs is a communal activity, often involving multiple generations, fostering a sense of community and shared responsibility.

The hardened cow dung discs serve multiple purposes in rural households. Primarily, they are used as bio-fuel for heating and cooking during the colder months. This use of cow dung as fuel is both cost-effective and environmentally friendly, reducing reliance on wood and other non-renewable resources.

Additionally, cow dung discs are used as insulation tiling in earthen-clay homes. This traditional construction technique offers natural insulation, keeping homes warm in winter and cool in summer. The cow dung also acts as a natural insect repellent as it will be mixed with small amounts of cow urine, helping to keep pests away. The use of cow dung in construction is a testament to the ingenuity of these communities in creating sustainable living environments using readily available resources. Adjustments can be made to the thickness of walls using wetted clay material, enhancing insulation properties.

Additionally, auxiliary layers such as straw flakes can be added to structures to improve their resilience against extreme weather conditions. These adaptations ensure that the age-old practices remain relevant and effective in contemporary times, reflecting a dynamic interplay between tradition and innovation.

The entire process—from the utilization of dairy products to the creation and use of cow dung discs—reflects a deep-seated cultural ethos of minimal waste and reverence for cows. Cows are seen as providers and nurturers, integral to the ecological and social fabric of rural life..

This reverence is manifested in numerous ways, from the daily care and feeding of cows to the celebration of festivals like Gopashtami, which honors the divine status of cows.

The cradle-to-cradle cycle in Indian communities, centred around the worship and utilization of ‘Gau Mata,’ is a remarkable example of sustainable living. By transforming waste into resources, these practices embody a holistic approach to sustainability, deeply rooted in cultural and religious traditions. As these communities continue to adapt to modern challenges, the enduring reverence for cows as sacred cattle remains a cornerstone of their way of life, offering valuable lessons in sustainability and respect for nature.

THE COW



B1

MOTHER



B2

FOOD	FEED	WASTE	WASTE + FOUND MATERIAL + USE
MILK	GRASS	<i>FIBER-RICH DUNG</i>	FIBER-RICH DUNG
PANEER	STRAW		+
GHEE		<i>LEFT OVER STRAW</i>	LEFT OVER STRAW
BUTTER	HOME- COOKED FOOD		+
			DRY HEAVY CLAY SOIL
			=
			...

PROCESS

WOMEN COMBING MATERIALS BY HAND TO FORM DISCS AND LAYING THEM TO DRY

B3, B4



HEAT



B5

INSULATION



B6

**WHY DOES
THIS
MATTER?**

**CROP WASTE
BURNING
=
AIR
QUALITY

HUMAN HEALTH

CLIMATE
CHANGE**



B7, B8, B9



World

Business

Markets

Sustainability

Legal

Breakingviews

Technology

Investigations

More

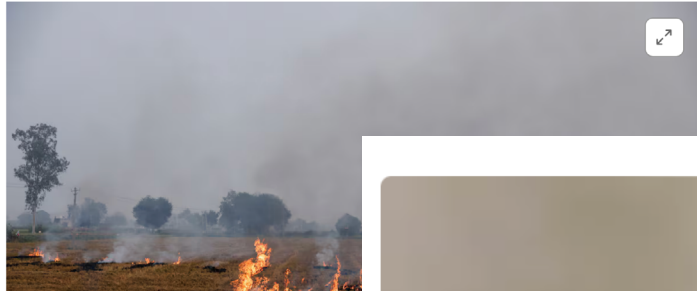
Climate & Energy | Climate Change

Indian farmers carry on burning stubble despite cost to health

By Manoj Kumar

November 6, 2023 9:08 PM PST · Updated 7 months ago

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16 AUG 2021 | STORY | AIR QUALITY

Toxic blaze: the true cost of crop burning



Crop Burning

19

←

Agricultural waste crop burning significantly impacts air quality by releasing large amounts of pollutants, including particulate matter (PM), carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These emissions contribute to smog formation and adverse health effects, particularly respiratory issues. In regions like North India and Oregon, crop residue burning has been a major source of air pollution, affecting both local and downwind areas. Efforts to reduce crop burning through alternatives and regulations are essential for improving air quality and mitigating climate change impacts (Hindustan Times, 2024; Oregon Invasive Species Council, 2024).

The lack of maintenance of slash piles in Oregon’s forests poses significant ecological and fire management challenges. Here in the Pacific Northwest, we’ve not been looking at the entire eco-cycle when managing forests. The neglect of slash piles has led to fires burning hotter and longer than previously recorded, allowing them to reach the crowns of trees and causing more extensive damage (“Impact of Slash Piles on Forest Fires”; “Traditional Forest Management Practices and Their Benefits”). By studying older, traditional ways of practice, we could learn how to utilize them to create a cradle-to-cradle cycle that respects the entire ecological cycle (“Impact of Slash Piles on Forest Fires”; “Traditional Forest Management Practices and Their Benefits”). Implementing these practices can help mitigate the risks associated with unmanaged slash piles, promoting healthier forest ecosystems and reducing the severity of wildfires (“Impact of Slash Piles on Forest Fires”; “Traditional Forest Management Practices and Their Benefits”).

→

**LACK OF
MAINTENANCE
=
WILDFIRES**

BAD ECO-CYCLE

**OFF GASED
CARBON**



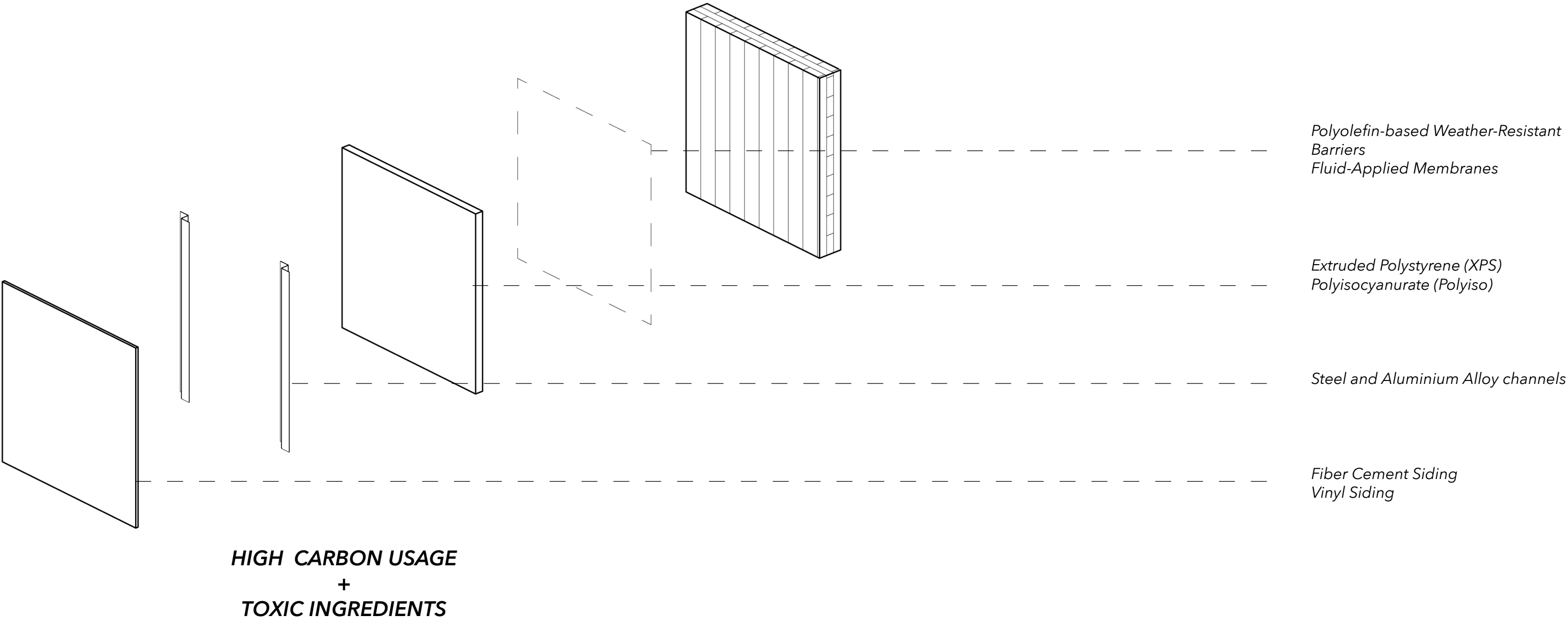
B10, B 11

MASS TIMBER?

Mass timber has been recognized as a carbon-sequestering alternative to concrete and steel in buildings.

However, less attention has been paid to the exploration of biogenic insulation and cladding materials which may be able to further reduce the carbon footprint of mass timber buildings.

CONVENTIONAL



PROBLEM?

Fiber cement siding is a popular choice due to its durability and aesthetic versatility, although it comes with a moderate to high carbon footprint because of the cement involved in its production (Green Building Canada; Siding Group; GreenBuildingAdvisor). This material also poses health risks during installation, as cutting or sanding can release silica dust, which is harmful when inhaled (HPD Consult; Safety+Health). Vinyl siding, while economical and low maintenance, has a significant environmental impact. It is made from polyvinyl chloride (PVC), which not only requires substantial energy to produce but also releases harmful dioxins during manufacturing and in the event of a fire (Siding Group).

Extruded polystyrene (XPS) is another commonly used insulation material known for its excellent thermal resistance. However, the production of XPS involves high global warming potential (GWP) blowing agents, contributing significantly to its carbon footprint (My Engineering Support; Quanda Plastic). Similarly, polyisocyanurate (polyiso) insulation offers high thermal efficiency but uses chemicals that emit volatile organic compounds (VOCs) during application, necessitating proper ventilation to safeguard installer and occupant health (My Engineering Support; Quanda Plastic).

Polyolefin-based weather-resistant barriers represent a more environmentally friendly option as they are derived from petroleum but processed in a way that is less intensive than other synthetic materials (My Engineering Support). These barriers are chemically inert, posing minimal risk of emitting toxic chemicals once installed. Fluid-applied membranes, used to protect buildings from water ingress, have a moderate carbon impact depending on their formulation and also require careful handling during application due to potential VOC emissions from solvents and other chemicals (My Engineering Support). Together, these materials highlight the trade-offs between performance and environmental impact in modern construction practices.

In summary, the selection of building materials such as fiber cement siding, vinyl siding, extruded polystyrene, polyisocyanurate insulation, polyolefin barriers, and fluid-applied membranes involves careful consideration of both their functional benefits and environmental impacts. While each material offers unique advantages in terms of durability and efficiency, they also present challenges including significant carbon footprints and potential health hazards from toxic chemical emissions during manufacturing and installation. As the construction industry continues to evolve, balancing these factors is crucial for sustainable building practices that meet both current needs and future environmental responsibilities.

BACKGROUND RESEARCH

**LET'S ZOOM OUT
AND SEE WHAT
THE REST OF
THE WORLD HAS
BEEN DOING**

**SPECIFICALLY,
REGIONS THAT
ARE PRODUCING
MASS TIMBER**



**FOR EACH OF THESE REGIONS I
LOOKED AT TRADITIONAL/
VERNACULAR:**

CLADDING

+

INSULATION



J3, J5, J8, J12, J19, J21, J23

In Japan, the history of natural building materials is deeply intertwined with its cultural reverence for nature and sustainability. Traditionally, materials such as wood and bamboo were predominantly used due to their availability and the flexibility they offered against earthquakes. Over the centuries, techniques such as the use of mud plaster and washi paper not only utilized locally sourced materials but also reflected a harmonious blend of functionality and aesthetic simplicity, characteristic of Japanese architecture.

SEE MATERIAL CATALOG APPENDIX FOR MORE DETAIL

In Australia and New Zealand, the use of natural building materials has historical roots in the indigenous practices of both countries, utilizing locally sourced wood and stone. Aboriginal Australians traditionally used materials like bark for shelters and structures, which was adaptable to the diverse climates across the continent. Similarly, Māori in New Zealand skillfully crafted buildings using timber, reeds, and flax, with techniques that emphasized durability and integration with the environment.

SEE MATERIAL CATALOG APPENDIX FOR MORE DETAIL

ANZ3, ANZ7, ANZ10, ANZ4, ANZ15, ANZ16, ANZ20

AUSTRALIA/ NEW ZEALAND

JAPAN

PACIFIC NORTHWEST - CLADDING

Western Red Cedar is renowned for its resistance to decay, insects, and moisture, making it an ideal choice for outdoor applications such as siding, decking, and fencing.

Its straight grain and uniform texture contribute to its aesthetic appeal, offering a timeless elegance to any project.

It's lightweight nature facilitates ease of handling and installation, while its natural oils provide inherent protection against weathering and rot.

PNW 3



Adobe bricks, crafted from a blend of clay-rich soil, sand, and straw, embody a timeless building tradition celebrated for its sustainability and resilience.

The material properties of adobe bricks showcase remarkable thermal mass, effectively moderating indoor temperatures by absorbing and releasing heat slowly.

Its simple production process, often employing locally available materials, underscores its eco-friendly appeal, reducing the carbon footprint associated with construction.

PNW 4



PNW 7

Cob, is crafted from a blend of clay, sand, and straw in varying proportions, yielding a rock-hard, finished structure.

With its origins rooted in English tradition, the term “cob” aptly reflects its essence, translating to “mud building” while also evoking imagery of loaf-like bricks.

Versatile and enduring, cob finds application in a myriad of structures ranging from quaint cottages and garden walls to sturdy benches and even ovens.

What sets cob apart is its intuitive construction process; devoid of molds or forms, cob is sculpted by hand onto a foundation, allowing for the creation of thick, load-bearing walls that bear the imprint of human craftsmanship.



PNW 9

Stone veneer, a popular choice in contemporary construction and design, is a versatile material that replicates the appearance of natural stone while offering enhanced flexibility and affordability.

Composed of thin slices or panels of natural or manufactured stone, stone veneer provides the aesthetic appeal of authentic stone without the weight or cost associated with traditional solid stone construction.

Its lightweight nature simplifies installation, allowing for easy application to various surfaces, including walls, fireplaces, and even exterior facades. Despite its slender profile, stone veneer maintains durability and weather resistance, ensuring longevity and low maintenance requirements. Stone veneer offers a diverse range of styles, colors, and textures.

INSULATION



Hemp cultivation requires minimal water and no pesticides. Beyond its eco-friendly credentials, hemp fiber insulation boasts excellent thermal insulation capabilities.

Hemp fibers are also mold-resistant and non-toxic, contributing to improved indoor air quality.

Hemp is used for cloth and other variety of products



Wood fiber insulation, a sustainable and eco-friendly alternative to traditional insulation materials, is made from shredded wood fibers, often sourced from recycled wood waste or sustainably managed forests.

This insulation material offers excellent thermal performance, effectively reducing heat loss and improving energy efficiency in buildings.

Wood fiber insulation is also known for its acoustic insulation properties, dampening sound transmission and enhancing acoustic comfort within buildings.

SUMMARY

Exploring these natural materials that already exist as building materials allows for the exchange of innovative ideas and technologies, enabling the development of more advanced and efficient materials. It allows regions to look at their histories for inspiration through a variety of material use and lets them evaluate how their modern technologies can integrate these materials.

Being a student is very important in this process, it is very easy to criticize processes from modern lens without any sort of context. It is crucial to be respectful about the stories of how practices and materials developed as it informs a more eco-cyclical process.

It promotes sustainability by utilizing local natural resources, reducing dependency on non-renewable materials, and potentially lowering environmental impact.

Studying bio-based materials from different regions can provide insights into their adaptation and performance in various climates and conditions, enhancing their applicability and resilience.

The redirection of waste streams is a concept I am passionate about and a lot of ancient materials were made of byproducts of other natural processes. Promoting the idea of waste use through studying what has been done in a time before us allows me to respect the stories of the people and blend modern technology with traditional practice.

INVASIVE SPECIES

WAIT...

IT DOES NOT END THERE

"An invasive species is an organism that is not indigenous, or native, to a particular area. Invasive species can cause great economic and environmental harm to the new area."

- National Geographic Society

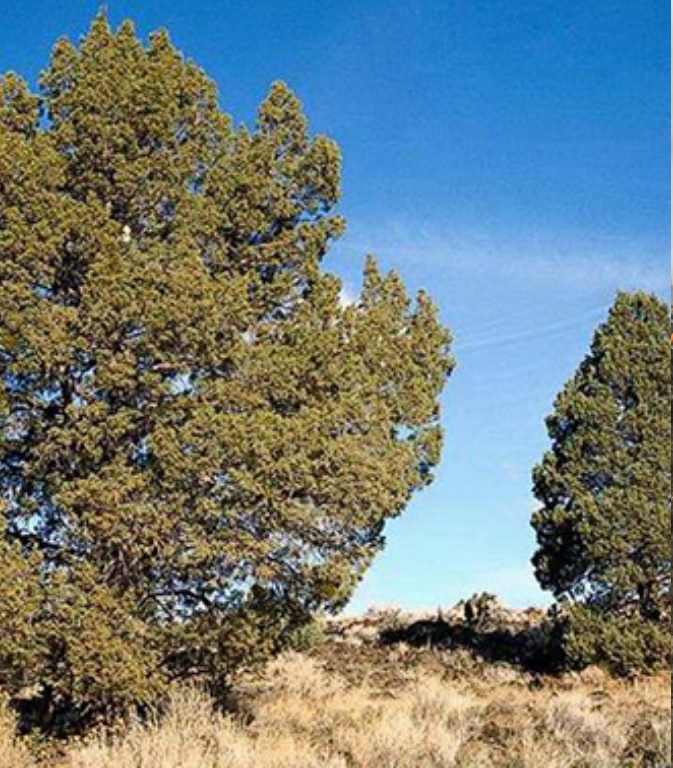
A FEW OF THE HUNDREDS OF INVASIVE SPECIES IN THE PACIFIC NORTHWEST

- TREE SPECIES
English Ivy (*Hedera helix*)
Scotch Broom (*Cytisus scoparius*)
Himalayan Blackberry (*Rubus armeniacus*)
Tree of Heaven (*Ailanthus altissima*)
English Holly (*Ilex aquifolium*)
Norway Maple (*Acer platanoides*)
Japanese Knotweed (*Reynoutria japonica*)
Japanese Holly (*Ilex crenata*)
Black Locust (*Robinia pseudoacacia*)
Russian Olive (*Elaeagnus angustifolia*)
English Laurel (*Prunus laurocerasus*)
Chinese Privet (*Ligustrum sinense*)
Princess Tree (*Paulownia tomentosa*)
Paper Mulberry (*Broussonetia papyrifera*)
Mimosa (*Albizia julibrissin*)
Sweet Briar Rose (*Rosa rubiginosa*)
Tree-of-Heaven (*Ailanthus altissima*)
Tamarisk (*Tamarix spp.*)
Western Juniper (*Juniperus occidentalis*)
Russian Vine (*Fallopia baldschuanica*)
Italian Buckthorn (*Rhamnus alaternus*)
English Oak (*Quercus robur*)
Silver Maple (*Acer saccharinum*)
Siberian Elm (*Ulmus pumila*)
Tree-of-Heaven (*Ailanthus altissima*)
Common Buckthorn (*Rhamnus cathartica*)
Chinese Tallow Tree (*Triadica sebifera*)
Japanese Stiltgrass (*Microstegium vimineum*)
Chinese Tallow Tree (*Sapium sebiferum*)
Saltcedar (*Tamarix spp.*)
Giant Knotweed (*Fallopia sachalinensis*)
Paperbark Maple (*Acer griseum*)
Butterfly Bush (*Buddleja davidii*)
Red Cedar (*Juniperus virginiana*)
Silverberry (*Elaeagnus commutata*)
Small-leaved Privet (*Ligustrum sinense*)
Black Cherry (*Prunus serotina*)
European Alder (*Alnus glutinosa*)
Sawtooth Oak (*Quercus acutissima*)
Common Pear (*Pyrus communis*)
Tartarian Honeysuckle (*Lonicera tatarica*)
Amur Maple (*Acer ginnala*)
Siberian Peashrub (*Caragana arborescens*)
Callery Pear (*Pyrus calleryana*)
Common Fig (*Ficus carica*)
Black Walnut (*Juglans nigra*)
Bradford Pear (*Pyrus calleryana* 'Bradford')
European Black Alder (*Alnus glutinosa*)
Oriental Bittersweet (*Celastrus orbiculatus*)
Autumn Olive (*Elaeagnus umbellata*)
Chinaberry (*Melia azedarach*)

- PLANT SPECIES
Giant Hogweed (*Heracleum mantegazzianum*)
Japanese Barberry (*Berberis thunbergii*)
Common Reed (*Phragmites australis*)
Japanese Honeysuckle (*Lonicera japonica*)
Garlic Mustard (*Alliaria petiolata*)
Japanese Spirea (*Spiraea japonica*)
Kudzu (*Pueraria montana*)
Purple Loosestrife (*Lythrum salicaria*)
Common Tansy (*Tanacetum vulgare*)
Dalmatian Toadflax (*Linaria dalmatica*)
Cape Ivy (*Delairea odorata*)
Yellow Flag Iris (*Iris pseudacorus*)
Scotch Thistle (*Onopordum acanthium*)
Periwinkle (*Vinca major*)
Japanese Stiltgrass (*Microstegium vimineum*)
Lesser Celandine (*Ranunculus ficaria*)
Japanese Spiraea (*Spiraea japonica*)
Chinese Wisteria (*Wisteria sinensis*)
Japanese Angelica Tree (*Aralia elata*)
Common St. Johnswort (*Hypericum perforatum*)
European Privet (*Ligustrum vulgare*)
Canada Thistle (*Cirsium arvense*)
Scotch Broom (*Cytisus scoparius*)
Giant Knotweed (*Fallopia sachalinensis*)
Japanese Knotweed (*Reynoutria japonica*)
Common Ragweed (*Ambrosia artemisiifolia*)
Russian Knapweed (*Rhaponticum repens*)
Gorse (*Ulex europaeus*)
Himalayan Knotweed (*Polygonum polystachyum*)
Spotted Knapweed (*Centaurea stoebe*)
Garlic Mustard (*Alliaria petiolata*)
Japanese Knotweed (*Reynoutria japonica*)
Giant Reed (*Arundo donax*)
Cheatgrass (*Bromus tectorum*)
Yellow Archangel (*Lamiaeum galeobdolon*)
Perennial Pepperweed (*Lepidium latifolium*)
White Sweetclover (*Melilotus albus*)
Yellow Sweetclover (*Melilotus officinalis*)
Black Medic (*Medicago lupulina*)
Common Teasel (*Dipsacus fullonum*)
Yellow Rocket (*Barbarea vulgaris*)
Hedge Parsley (*Torilis arvensis*)
False Indigo (*Amorpha fruticosa*)
Creeping Bellflower (*Campanula rapunculoides*)
Himalayan Blackberry (*Rubus armeniacus*)
American Skunk Cabbage (*Lysichiton americanus*)
Japanese Mugwort (*Artemisia princeps*)
Moneywort (*Lysimachia nummularia*)
Japanese Knotweed (*Reynoutria japonica*)
Giant Salvinia (*Salvinia molesta*)

WESTERN JUNIPER

The encroachment of western juniper into grasslands and sagebrush steppe ecosystems can lead to reduced plant diversity, altered hydrology, and changes in wildlife habitat. Efforts to manage western juniper involve selective cutting or controlled burns to mitigate its impact on ecosystems and restore the balance between juniper woodlands and native vegetation.



IS1, IS2



GORSE

An invasive shrub in the Pacific Northwest, gorse features spiky leaves and bright yellow flowers, reaching heights of 6 to 10 feet. Native to Europe, it poses a threat in the PNW due to its rapid growth and flammability. Gorse’s hard-coated seeds and root suckers contribute to its invasive spread, impacting native vegetation and elevating the risk of wildfires. Control measures involve mechanical removal, herbicides, and prescribed burns to protect ecosystems and reduce fire hazards

IS3, IS4

Burning invasive plant material releases significant amounts of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These emissions come not only from the combustion process itself but also from the decomposition of plant material that occurs when invasive species alter soil microbial communities. This can lead to increased greenhouse gas emissions, exacerbating climate change impacts (Kansas State University Research and Extension, 2024; PLOS ONE, 2024).

Invasive plants can disrupt normal carbon storage processes in soils. Studies show that when invasive species like certain fast-growing plants are introduced, they can change the composition and activity of soil microbes, leading to increased soil respiration rates. This results in the release of more CO₂ from the soil into the atmosphere, thus reducing the soil's ability to act as a carbon sink (Popular Science, 2024).

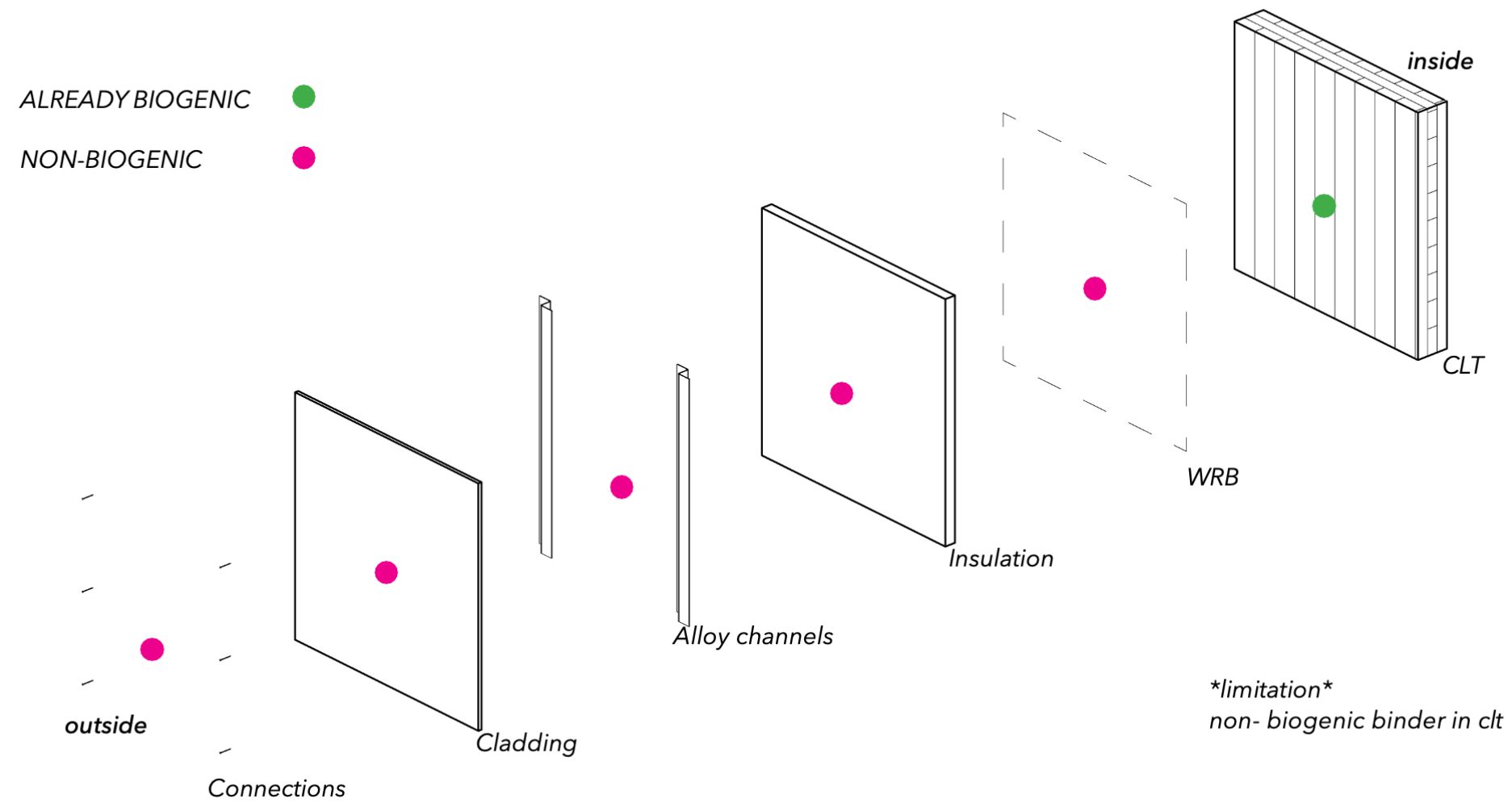
Prescribed burns, used to manage invasive species, have been found to offset some methane emissions from cattle grazing systems. However, these benefits are context-specific and depend on the management practices and ecological conditions of the area being burned. While prescribed burns may help control certain invasive species, they also contribute to carbon emissions and need to be carefully managed to minimize their environmental impact (Kansas State University Research and Extension, 2024).

Invasive species management through burning can have broader environmental consequences, such as altering ecosystem dynamics, affecting native species, and potentially worsening climate change impacts. Invasive plants often grow faster than native species, changing the carbon balance in ecosystems by increasing the rate of organic matter decomposition and CO₂ release (Popular Science, 2024).

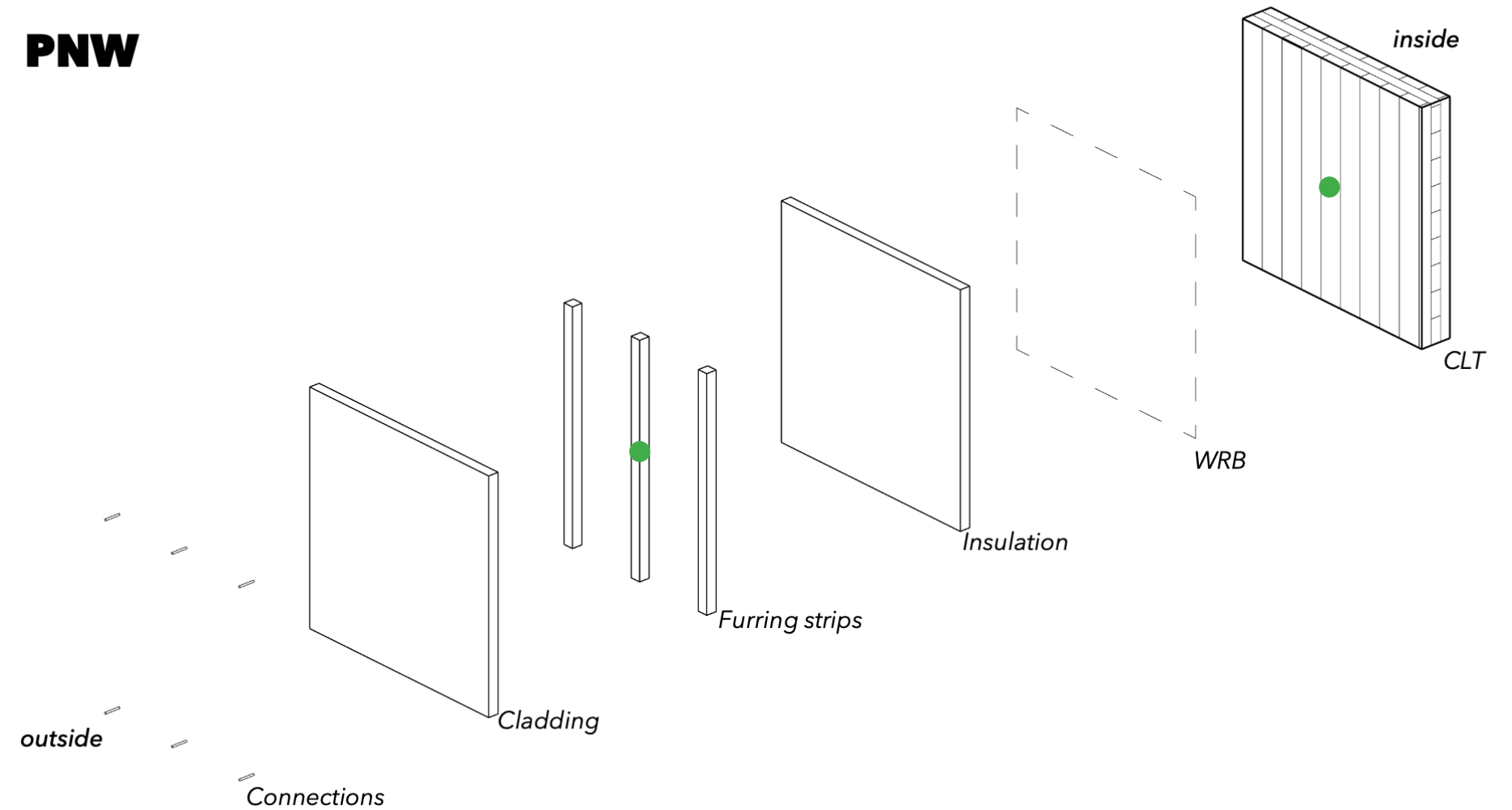
SO WHAT DO WE DO WITH ALL THIS BACKGROUND RESEARCH?

LET'S START MAKING





PNW



**CLT has non-biogenic binders within it.
There is work being done on natural binders
but for the experiment this was the cheapest
to source**

CLADDING

WESTERN JUNIPER
+
PHENOL FORMALDEHYDE

OSU PROFESSOR
SCOTT LEAVENGOOD
DEPARTMENT OF
WOOD SCIENCE AND
ENGINEERING

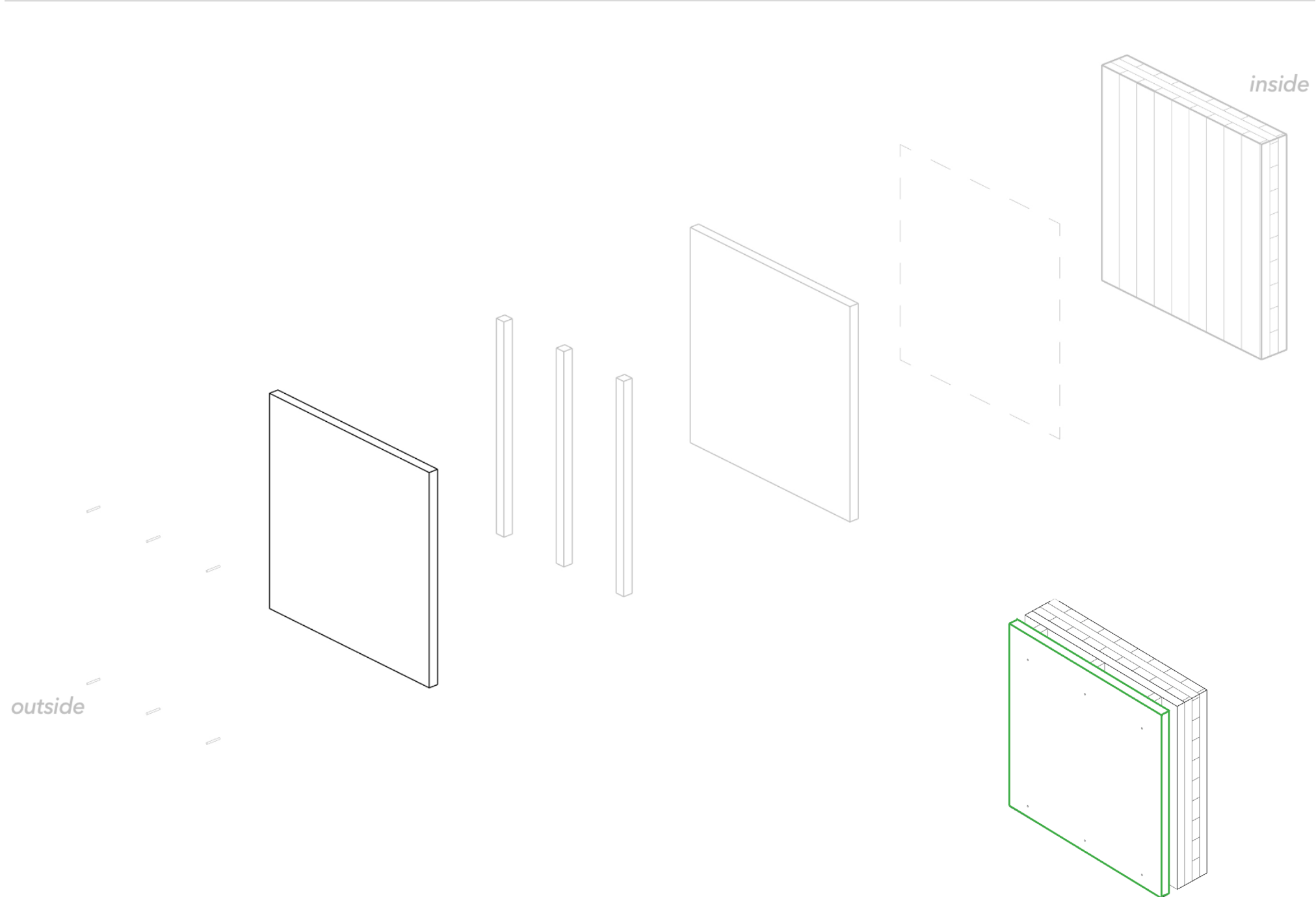
The invasive Western juniper significantly impacts farmers in Oregon by disrupting the natural ecosystem and reducing the productivity of agricultural lands. As Western juniper trees spread, they consume large amounts of water, which diminishes the availability of this critical resource for crops and livestock. This water competition is particularly problematic in arid regions, where water is already scarce.

The dense canopies of juniper trees also create heavy shade, suppressing the growth of grasses and other forage plants that are essential for grazing livestock.

Currently Juniper is just being chipped and burnt off as it is a difficult material to mill. I believe that finding use for materials for invasive species like this creates a better eco-cycle that respects a cradle-to-cradle approach.

**Phenol Formaldehyde is not biogenic
but is said to offgass 90% less than Urea
Formaldehyde glue(www.3littleplums.com)**





INGREDIENTS

- JUNIPER WAFERS/STRANDS FROM CORVALLIS FARMER WASTE
- PHENOL FORMALDEHYDE (NON-OFFGASING)
- RELEASE AGENT(SOAP AND WATER)
- HEAT

EQUIPMENT

- A LARGE SPINNING DRUM/ KITCHENAID
- HOSE AND PUMP
- A BINDER DISTRIBUTION NOZZLE (RUNS AT 10, 000RPM)
- SCALE UP TO 50.0KG FOR STRANDS
- SCALE UP TO 5.000KG FOR BINDER
- A LARGE TUB TO TRANSFER + WEIGH MATERIAL
- SCOOP/ DUST PAN
- FORMWORK 32X32" WITH ADJUSTABLE HEIGHT
- ALUMINIUM PLATES 32X32" (QUICK HEAT LOSS)
- INDUSTRIAL OVEN MITTS
- CLIFTON HYDRAULIC PRESS
- BROOM
- FACE MASKS FOR FINE PARTICLES

PROCESS

1. CALCULATE DESIRED DENISTY OF BOARD THROUGH EXCEL FORM
2. WEIGH OUT WAFERS/STRANDS
3. WEIGH OUT BINDER
4. PLACE STRANDS IN DRUM
5. RUN DRY
6. START THE DISTRIBUTING NOZZLE AND GET IT UP TO SPEED
7. INSERT HOSE THAT RUNS THROUGH A MECHANICAL PUMP INTO BINDER
8. PUMP WEIGHED OUT BINDER INTO DRUM IN WHICH THE NOZZLE WILL DISTRIBUTE
9. AFTER ALL BINDER IS OUT OF HOSE SHUT IT OFF
10. KEEP DRUM SPINNING FOR 10 MINUTES FOR A GOOD COAT OF BINDER ON STRANDS
11. WHILE SPINNING, PREPARE THE
12. FORMWORK
13. PLACE DOWN ALUMINIUM SHEET AS BASE AND COAT VERY LIGHTLY IN RELEASE AGENT
14. ADD WALLS OF FORMWORK TO THE BASE
15. STOP SPINNING THE DRUM AND TRANSFER SUBSTRATE INTO FORM WORK
16. TAKE OUT ANY CONTAMINANTS LIKE ROCKS OR BIG CHUNKS
17. SPREAD EVENLY TO GET A ROUGHLY UNIFORM SURFACE AND TAMP THE STRANDS
18. ADD ANOTHER ALUMINIUM SHEET WITH RELEASE AGENT AFTER REMOVING THE TAMP
19. PUT ON OVEN MITTS AND CARRY YOUR ALUMINIUM+ STRAND SANDWICH TO THE HYDRAULIC PRESS AND START THE PRESS SEQUENCE.
20. (NOTE- IF THERE IS TOO MUCH STEAM BUILD UP, THE BOARD WILL BLOW APART)
21. WITH GLOVES ON TAKE OUT THE SHEET SANDWICH AND LET THE BOARD COOL
22. TRIM THE EDGES
23. SAND
24. APPLY FINISH

WEIGH



COMBINE



FORM



SQUARE



FINISH



INSULATION

MYCELIUM + STRAW

Collab: CHARRLOTTE
KAMMAN

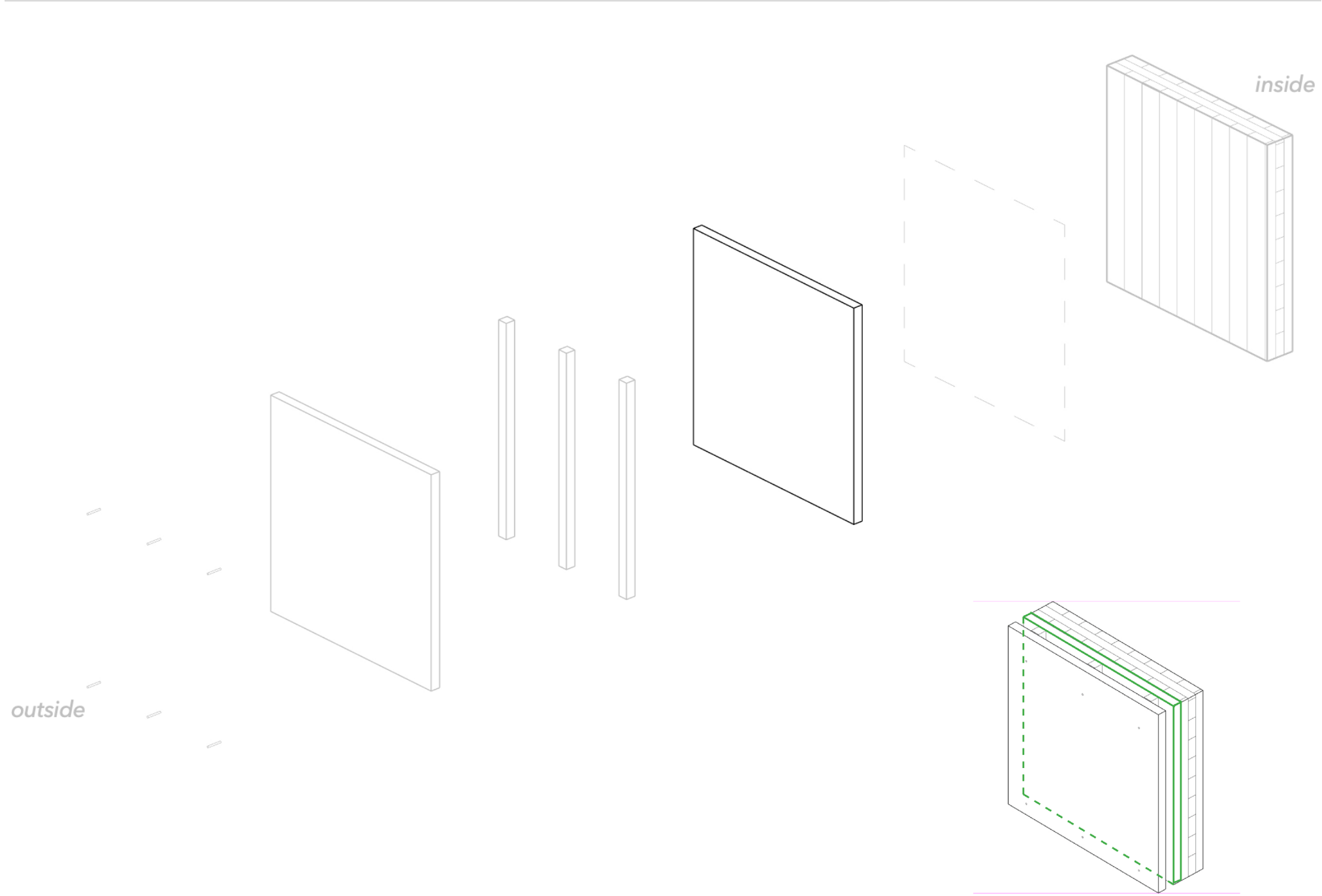
Researchers are studying mycelium due to its versatility in variety, mechanical properties and accessibility.

Mycelium, the vegetative part of fungi, can be grown into various shapes and forms, making it a promising material for various functions and in this projects case, insulation

Its natural properties allow it to decompose organic waste and pollutants, which can be harnessed for environmental remediation efforts.

I chose mycelium as the PNW is world renowned for its library of fungi. With the knowledge that it is able to grow on waste streams such as straw, wood fiber, hemp etc it was only natural to move further in the exploration





INGREDIENTS

GRAIN SPAWN

SUBSTRATE- STRAW

BOILING WATER/ STEAM

EQUIPMENT

TABLE SAW

NAIL GUN

PLYWOOD

CLING WRAP

HOT PLATE

LARGE POT

ETHANOL(CLEANING)

BLADE

HEATER

GOVE HUMIDITY AND TEMPERATURE SENSOR

LOW LIGHT SPACE

NITRILE GLOVES

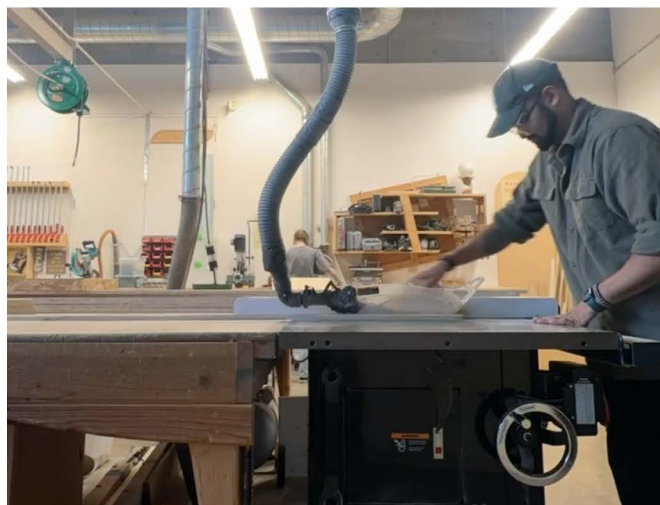
DEHYDRATOR/ OVEN

BUCKETS

PAPER TOWEL

PROCESS

1. CUT DOWN PLYWOOD TO MAKE DESIRED SIZE FORMWORK
2. CALCULATE AMOUNT OF GRAIN SPAWN NEEDED TO INNOCULATE PASTERISED SUBSTRATE
3. PASTERISE THE SUBSTRATE BY STEAMING OR BOILING IT
4. SPRAY ALL SURFACES WITH ETHANOL INCLUDING GLOVES AND EXTERIOR OF SPAWN BAG
5. WEIGH OUT SUBSTRATE INTO DISINFECTED BUCKET
6. WEIGH OUT GRAIN SPAWN AND MIX THOROUGHLY INTO THE SUBSTRATE
7. CLEANSE FORMWORK WITH ETHANOL
8. PLACE DOWN CLING WRAP TO MOLD THE FORMWORK
9. FILL FORMWORK WITH INNOCULATED SUBSTRATE
10. SEAL OVER WITH ANOTHER LAYER OF CLING WRAP
11. LET MYCELIUM GROW FOR A 2-4 WEEK PERIOD IN A DARK ROOM WITH A TEMPERATURE LEVEL OF 72-78F
12. TRIM FRUITING BODIES WITH A ETHANOL DIPPED BLADE
13. PEEL OUT MYCELIUM FROM CLING WRAP AND DRAIN EXCESS MOISTURE
14. DAB DRY
15. PLACE ON RACKS AND ALLOW TO GET TO A MOISTURE LEVEL OF LESS THAN 5% IN A DEHYDRATOR RUNNING AT 160F. THE TIME MAY VARY AS VARIOUS SIZES HAVE VARIOUS DRYING TIMES



3 DAYS



10 DAYS



15 DAYS



21 DAYS



25 DAYS



DRIED







WEATHER RESISTANT BARRIER BIOPLASTIC

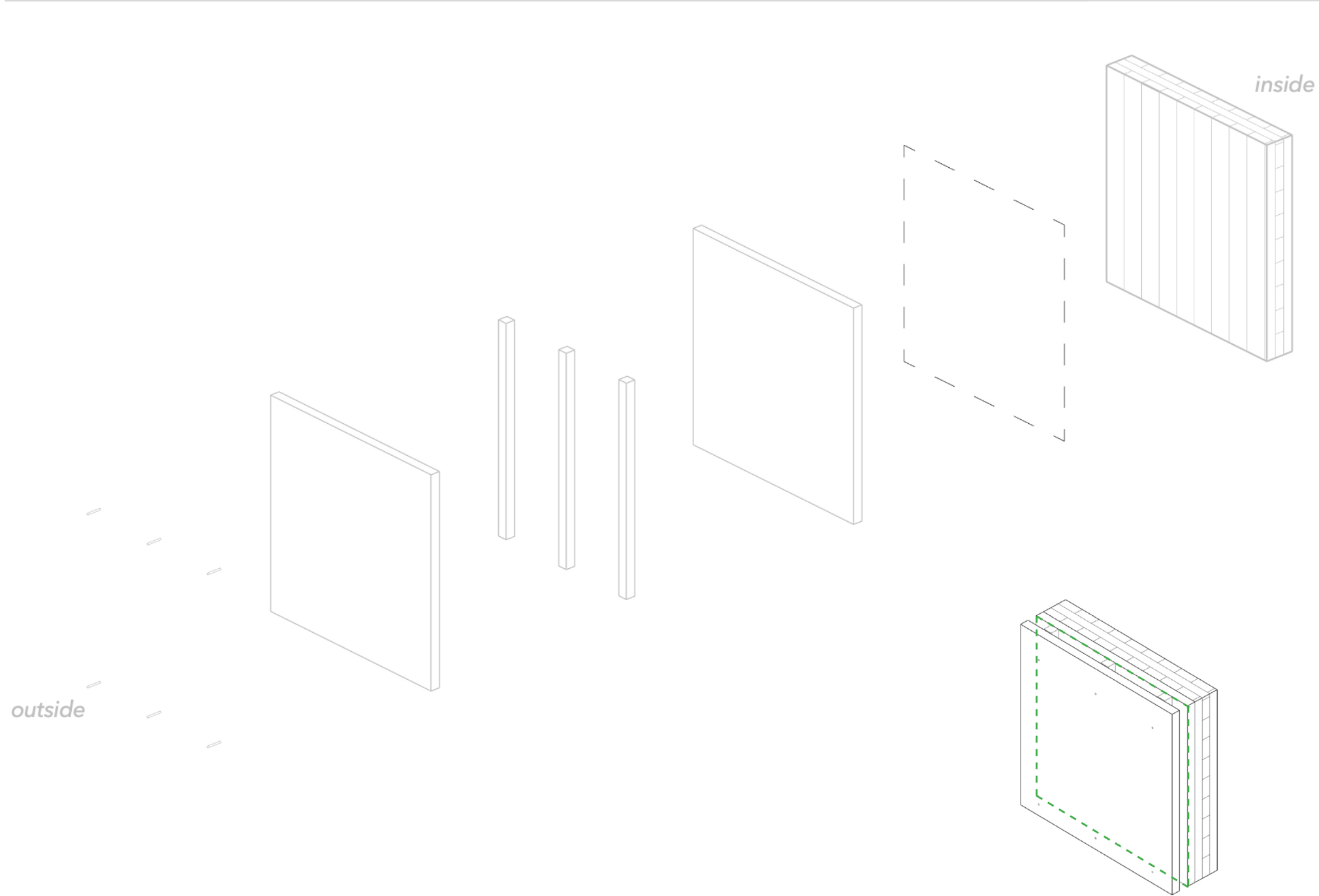
An attempt at pushing the boundary of how biogenic can we get.

Dr Mark Fretz suggested the use of Scobi which is used to make kombucha but I was skeptical and pursued further avenues of research. I came across bioplastic after a video appeared in social media and I was hooked. I then read further and saw that this was something American students learnt about and featured in science competitions.

Bioplastics are making a comeback and are more popular than ever in the design research field.

A process so simple that yields beautifully complex results.





INGREDIENTS

- 7 TBLSPN WATER
- 2/3 TBLSPN GLYCERIN
- 2/3 TBLSPN DISTILLED WHITE VINEGAR
- 1 TBLSPN VEGETABLE STARCH(CORN STARCH)
- (TBLSPOON CAN BE CHANGED TO ANY MEASUREMENT DEPENDING ON SHEET DENSITY OR SIZE)

EQUIPMENT

- HEAT REISISTANT MIXING BOWL
- MEASURING SPOONS
- POT
- STOVE TOP
- OVEN GLOVES
- ALUMINIUM FOIL
- LARGE TABLE/ SURFACE
- SILICONE BAKING SPATULA
- WATER FOR BOILING

PROCESS

1. PUT A POT OF WATER ON THE STOVE TO BOIL
2. LAY OUT ALUMINIUM SHEET FOR THE SIZE OF SHEET DESIRED, YOU CAN FOLD UP THE EDGES IF MORE DEPTH IS DESIRED
3. MIX ALL THE INGREDIENTS IN THEIR GIVEN RATIOS USING THE SPATULA
4. BRING THE BOWL OVER THE POT OF BOILING WATER
5. STIR AND MIX UNTIL THE MIXTURE FORMS CHUNKS
6. KEEP STIRRING UNTIL YOU GET A HOMOGENOUS SOLUTION THAT IS THICK AND TRANSLUCENT
7. REMOVE BOWL FROM ABOVE THE BOILING WATER AND ALLOW FOR 3 MINUTES OF COOLING TIME
8. USING THE SAME SPATULA SPREAD THE MIX ONTO THE ALUMINIUM FOIL, BE CAREFUL NOT TO SPREAD TOO THIN AS THIS WILL CAUSE CRACKS.

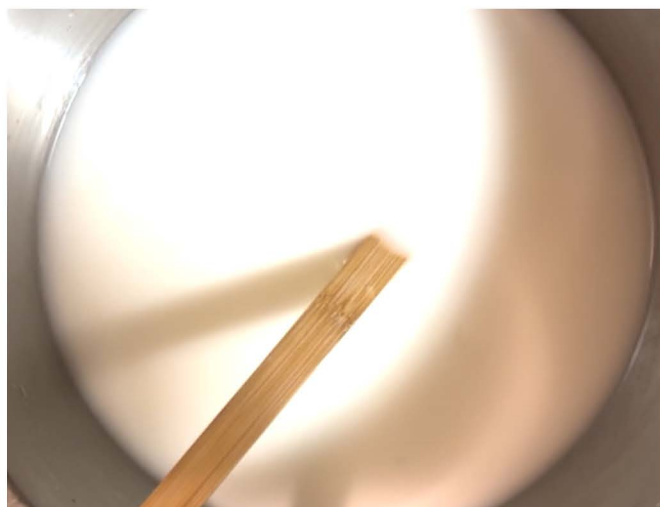
RATIO OF INGREDIENTS

7 TBLSPN WATER
2/3 TBLSPN GLYCERIN
2/3 TBLSPN DISTILLED WHITE VINEGAR
1 TBLSPN VEGETABLE STARCH(CORN STARCH)

STEPS:

MIX
DOUBLE BOIL UNTIL OPAQUE
SPREAD
DRY OVER 10 DAYS



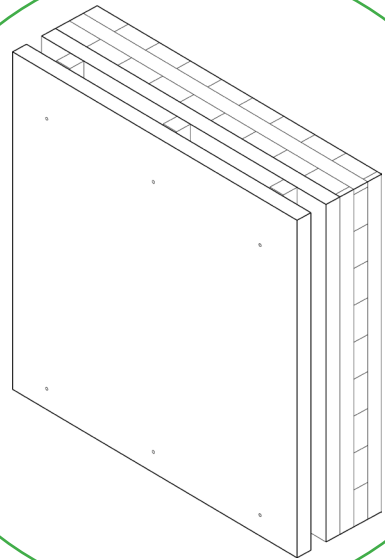




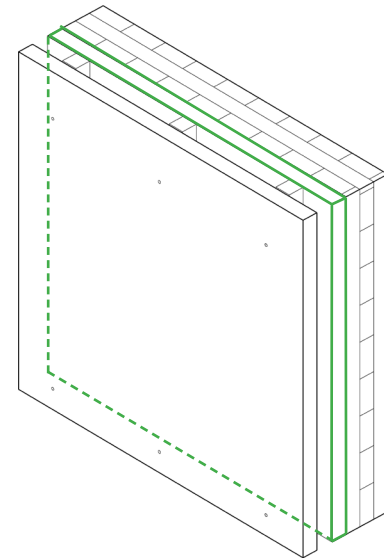
TESTING

While creating materials and enjoying the process is important, it is essential to validate their efficacy through rigorous testing. Conducting systematic tests is necessary to establish the reliability and performance of these materials. Only through evidence and analysis can we ensure their suitability for practical applications and gain confidence in their effectiveness. This allows us to understand the performance and evaluate what changes we can make in future research to enhance these materials.

ACOUSTIC



THERMAL



**WOOD FIBER
VS
MYCELIUM**



ACOUSTIC



ACOUSTIC



EQUIPMENT

- SHOP VACUUM
- AIR FILTER
- MALLET
- SAND LEVELING JIG
- MICRO ACOUSTIC CHAMBER WITH ALL COMPONENTS
- LOTS OF SAND
- MUTLIPL 10 GALLON BUCKETS
- CLING WRAP
- ALL FABRICATED MATERIALS TO FIT 32 X 32" ASSEMBLY
- OMNIPOWER SOUND SOURCE (4292-L-001)
- POWER AMPLIFIER (2734-B), MICROPHONE
- PRE-AMPLIFIER MICROPHONE (4189 & ZC-0032)
- SOUND ANALYZER (2270–D01),
- SOUND CALIBRATOR (4231)

PROCESS - SET UP

1. SWITCH ON AIR FILTERS TO CATCH FINE DUST PARTICLES
2. EMPTY SAND PARTICLES OUT USING A SHOP VACCUUM AND SCOOPS TO DESIRED HEIGHT(FOR STARTING A NEW TEST- EMPTY SAND UNTIL THE LEVEL IS BELOW THE CLT PANEL SO THAT IT MAY BE REMOVED TO PUT IN THE SAMPLE THICKNESS YOU DESIRE || FOR A CONTINUED TEST WITH THE SET CLT THICKNESS- EMPTY SAND UNTIL YOU GET TO THE TOP PLY OF THE CLT AS ALL THAT NEEDS REPLACING IS THE INSULATION)
3. PLACE SAND INTO 10 GALLON BUCKETS FOR FILLING THE ACOUSTIC CHAMBER LATER
4. REMOVE THE CLT
5. CLIMB INTO CHAMBER WITH MIC CALIBRATION DEVICE AND PLACE IT OVER THE HEAD OF THE MIC THAT IS SUSPENDED IN THE CHAMBER AND RUN A SET CALIBRATION TEST OF 30 SECONDS
6. CALIBRATE THE EXTERIOR MIC
7. LOAD ON DESIRED CLT THICKNESS WITH EXTERIOR ASSEMBLY
8. IN OUR SPECIFIC CASE, I MODELED A RAIN SCREEN ASSEMBLY TYPICAL OF THE PACIFIC NORTHWEST WHICH INCLUDES FURRING STRIPS.
9. THIS MEANS THAT SAND WILL LEAK INTO THE ASSEMBLY AFFECTING RESULTS AND THUS WE WRAP AND SEAL THE EDGES OF THE ASSEMBLY WITH SIMPLE CLING WRAP TO PROTECT OUR MATERIALS AND MITIGATE SAND INFILTRATON.
10. MAKE SURE THAT THE PANEL IS LEVEL AND IS SITTING FLUSH WITH ALL THE FOAM GASKETS AT THE MOUTH OF THE CHAMBER TO AVOID ANY SOUND LEAKS IN THE EDGES OF THE PANEL
11. USING THE CIOLLECTED SAND FROM EARLIER, FILL UP SAND TO ABOUT AN INCH BELOW THE TOP EDGE OF THE ASSEMBLY.
12. USING THE LEVELING JIG, EVEN OUT THE SAND ON THE EDGES OF THE ASSEMBLY SO THAT THERE ARE NO AIR GAPS OR PEAKS IN THE SAND FOR THE SEALING "DONUT" JIG.
13. PLACE THE DONUT RING OVER THE SAND, ENSURING A SMALL GAP BETWEEN THE RING AND YOUR ASSEMBLY(1/8TH OR 1/16TH")
14. USING A MALLET- KNOCK DOWN THE EDGES OF THE DONUT TO ENSURE THAT IT IS FLAT AND THIS ALLOWS FOR THE SAND TO EVEN OUT UNDER THE PANEL AS WELL.
15. THIS GAP ALLOWS YOU TO FILL IN SAND AND ENSURE A TIGHT SEAL AROUND YOUR ASSEMBLY.
16. BRUSH OFF AND VACUUM EXCESS SAND.
17. USING PLUMBERS PUTTY- SEAL THE OUTER AND INNER EDGES OF THE DONUT.
18. PLACE THE EXTERNAL MIC OVER THE CENTER OF THE ASSEMBLY.
19. ON A PIECE OF PAPER- WRITE DOWN TEST TYPE, TIME STAMP AND TEST NUMBER.
20. THERE ARE 2 TYPES OF TEST FOR A WALL ASSEMBLY- AIRBORNE TESTING AND BACKGROUND TEST.

PROCESS - TESTING

1. PLACE EXTERNAL MIC ABOVE CENTER OF PANEL
2. WAIT FOR ALL CARS AND OUTSIDE NOISE TO SUBSIDE.
3. BE QUIET.
4. PERFORM 30 SECOND BACKGROUND TEST.
5. REPEAT TEST 3 TIMES.
6. PUT ON EAR PROTECTION.
7. RUN 13 SECOND AIRBORNE TEST AND REPEAT THIS 3 TIMES
8. THE SPEAKER PLAYS A RANGE OF FREQUENCIES FROM 50HZ - 50 000HZ
9. YOU WILL GET 2 READINGS, INSIDE AND OUTSIDE OF THE BOX
10. THEN YOU GO BACK TO TAKING OUT THE SAND FOR THE NEXT TEST

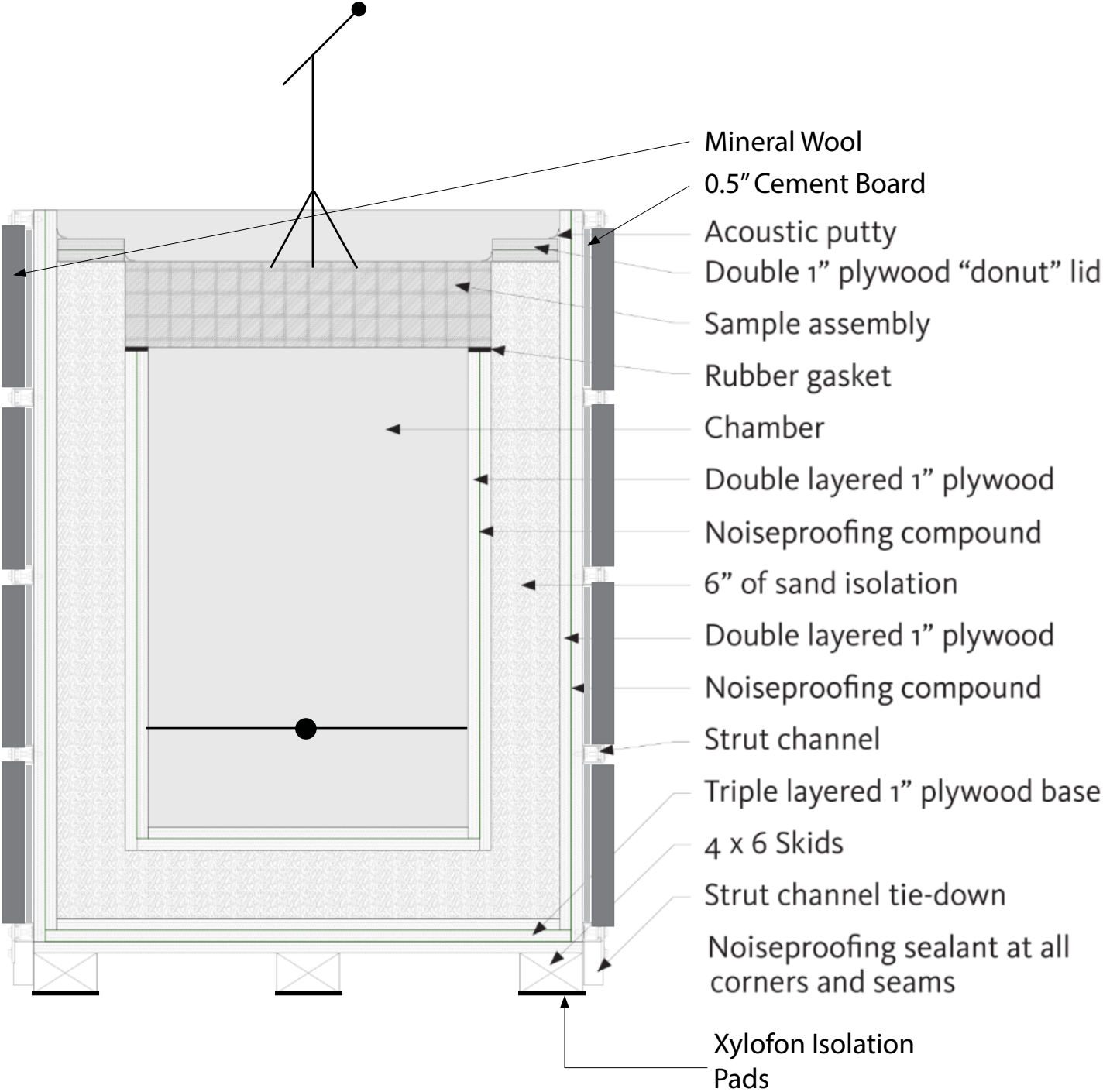
TEST TYPES

BACKGROUND

A background acoustic test, also known as a background noise measurement, is an essential part of acoustic testing used to assess the ambient noise levels in a given environment. This type of test is crucial in various settings, including residential, commercial, industrial, and military applications. The primary goal of a background acoustic test is to measure and account for existing noise levels from external sources, such as traffic, weather, and other environmental factors that could influence the results of more specific acoustic measurements, like sound insulation or reverberation tests.)

AIRBORNE

An airborne acoustic test, also known as an airborne sound insulation test, measures the capacity of a building element, such as a wall, floor, or ceiling, to block the transmission of airborne sound from one side to the other. This test assesses the effectiveness of these structures in reducing noise levels and ensuring sound privacy and comfort in buildings. The performance is quantified by comparing the sound pressure levels in the source and receiving rooms, accounting for reverberation time and background noise. The results are typically expressed using metrics like the weighted standardized level difference (DnT,w) and a correction term for low-frequency noise (Ctr), indicating the building element's overall sound insulation capability.



Drawing credit: IHBE

VISUAL BREAKDOWN



turn on air filters to catch fine dust particles

empty sand particles out using a shop vacuum and scoops to desired height

place sand into 10 gallon buckets for later use



*remove any previous samples
to expose the internal
microphone*



*the samples usually exceed
40lbs and due to the size of
the chamber are high off the
ground, make sure you have
adequate lifting equipment like
a gantry crane.*



climb into the chamber carefully, use a sound calibrator to calibrate and reset the microphone.

readjust all the edge rubber gaskets as well.

you will also have to calibrate the external microphone with the same device.



place in your new structural sample(3 PLY CLT)



make sure it is level and is sealed tight to the mouth of the chamber on all edges.

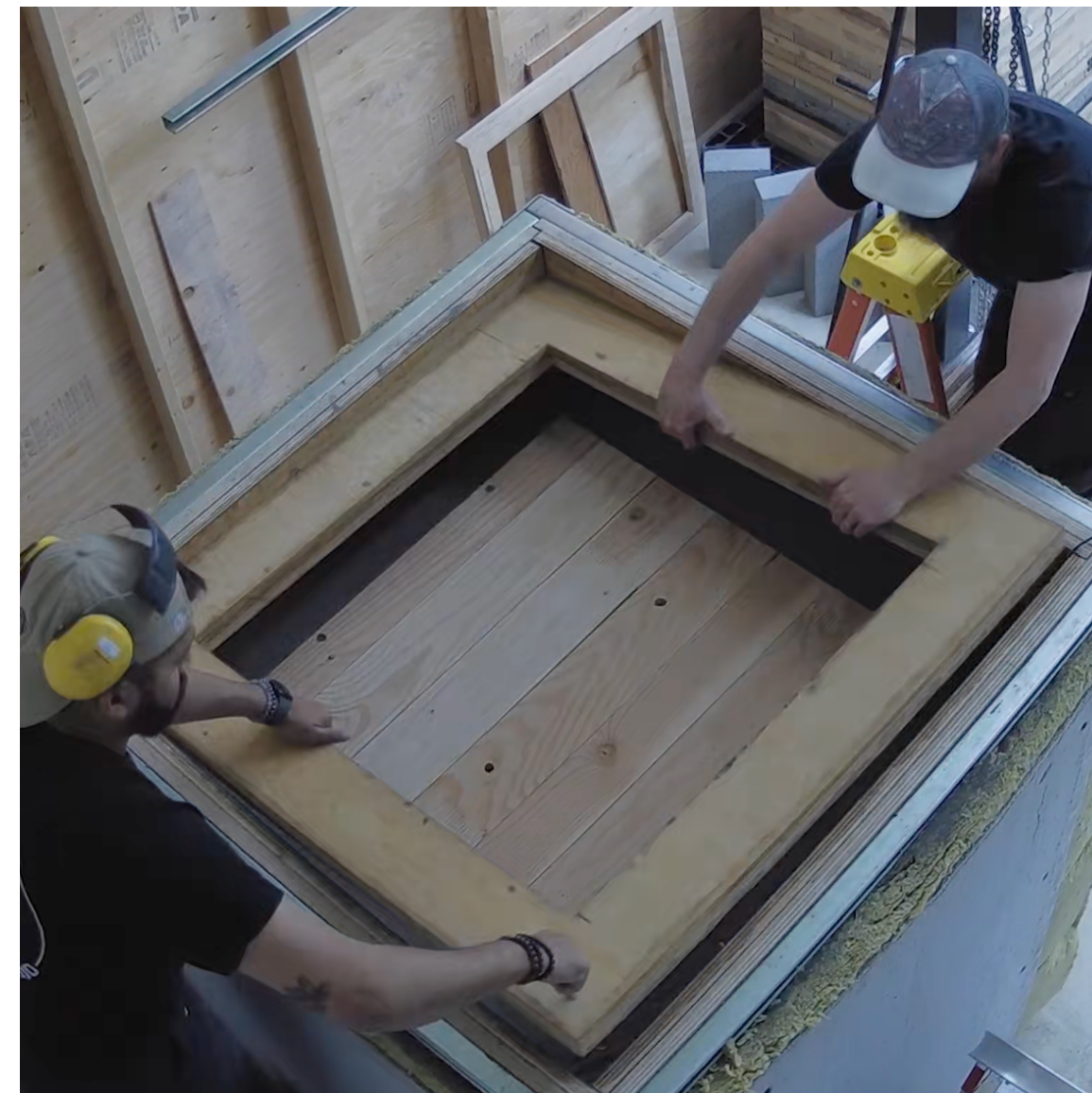
add new foam gaskets in case it is not level



add back the collected earlier collected sand until you reach about an inch under the top edge of the sample.



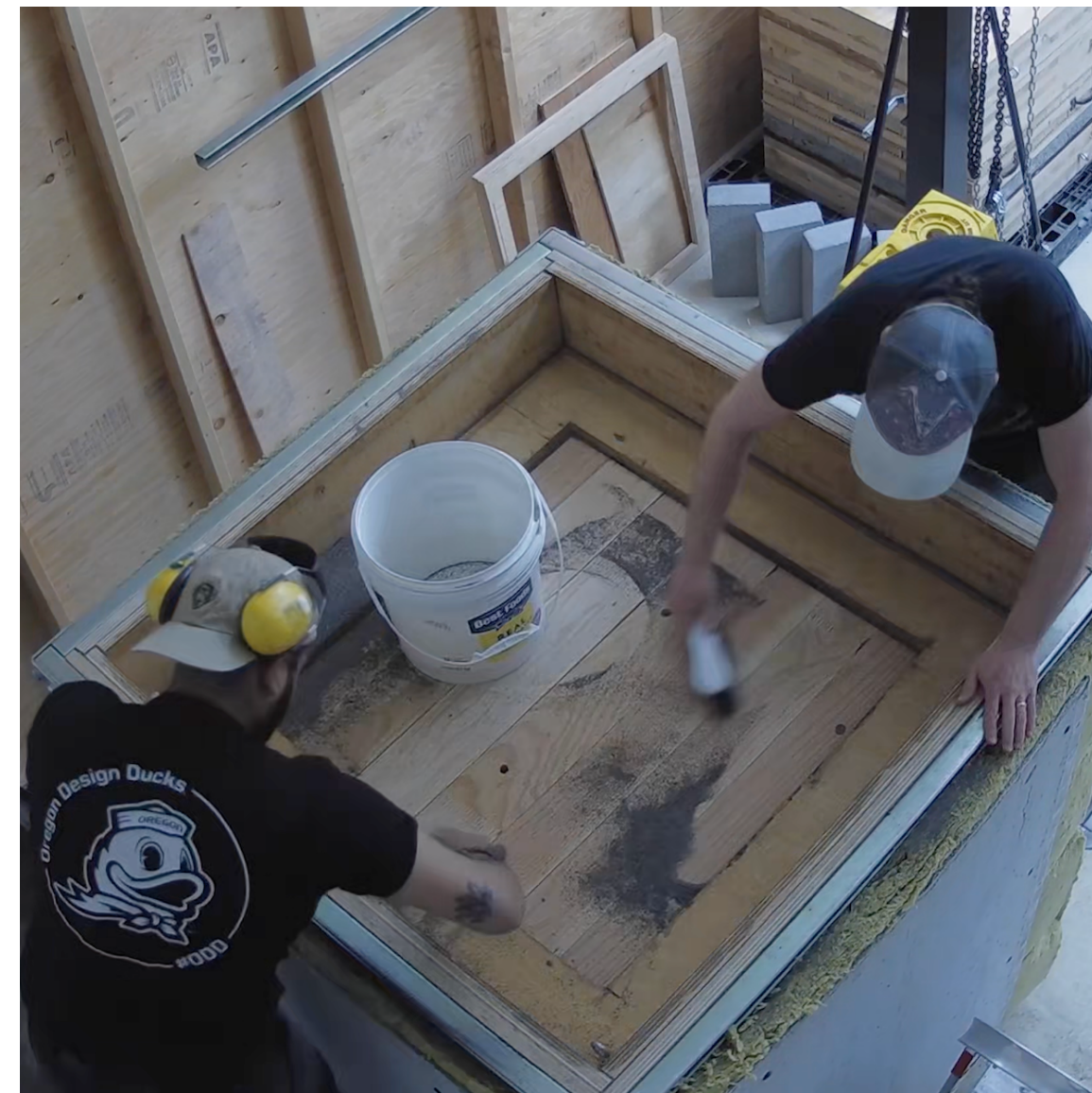
using a customised level jig, ensure all the sand is level around the panel, mitigating potential air gaps and removing excess sand



place on the 'donut' sealing ring, allowing for a small gap (1/8 ") around the edge of the panel and sample to fillin sand gaps



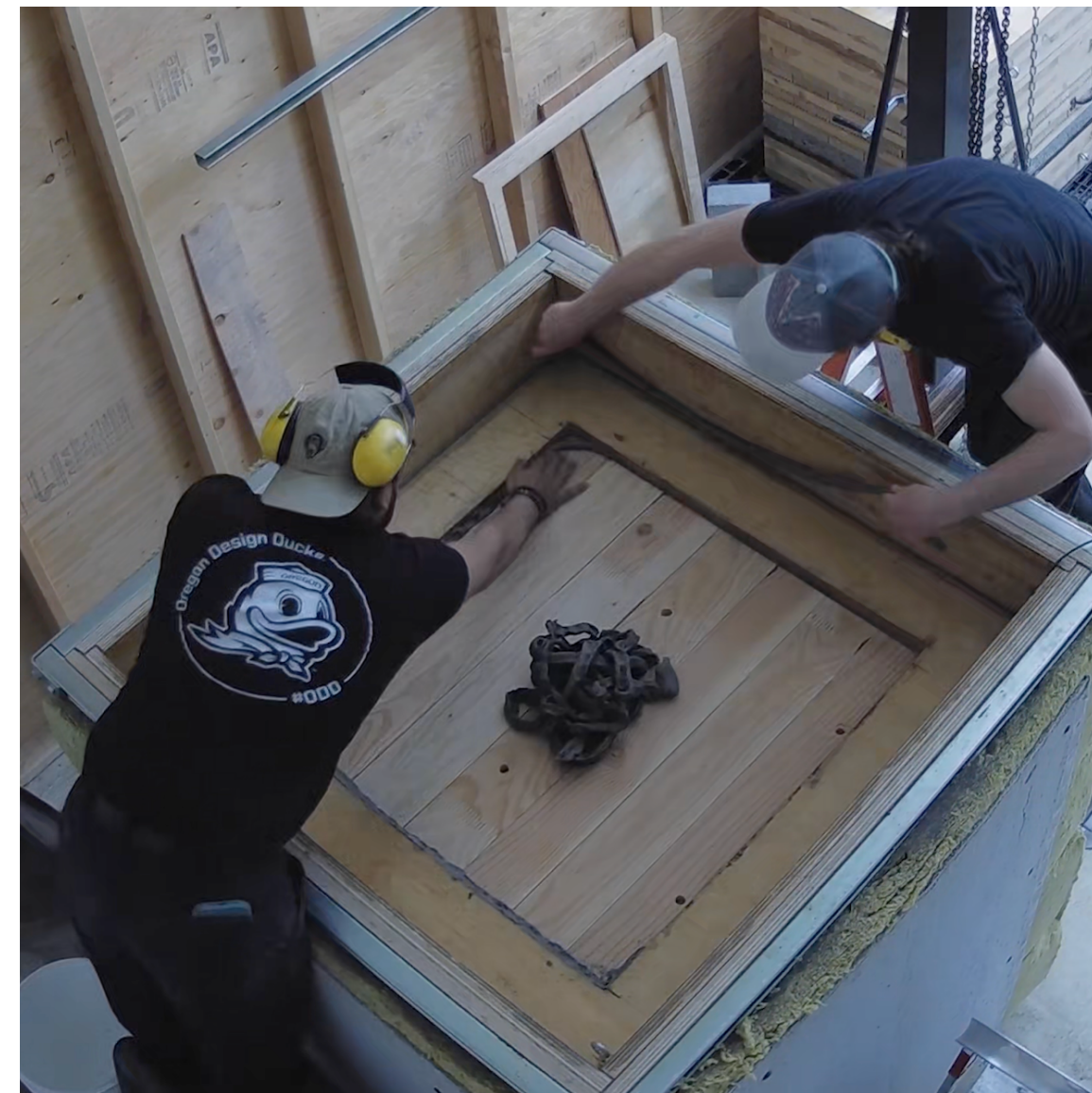
place on the 'donut' sealing ring, allowing for a small gap (1/8 ") around the edge of the panel



fill in those created gaps with extra sand



*using a non-setting putty,
form noodles*



*using your thumb press
the putty into the gaps
using a lot of force
ensuring that it sticks.*



place your external microphone above the center of the assembly you are testing



conduct background and airborne tests



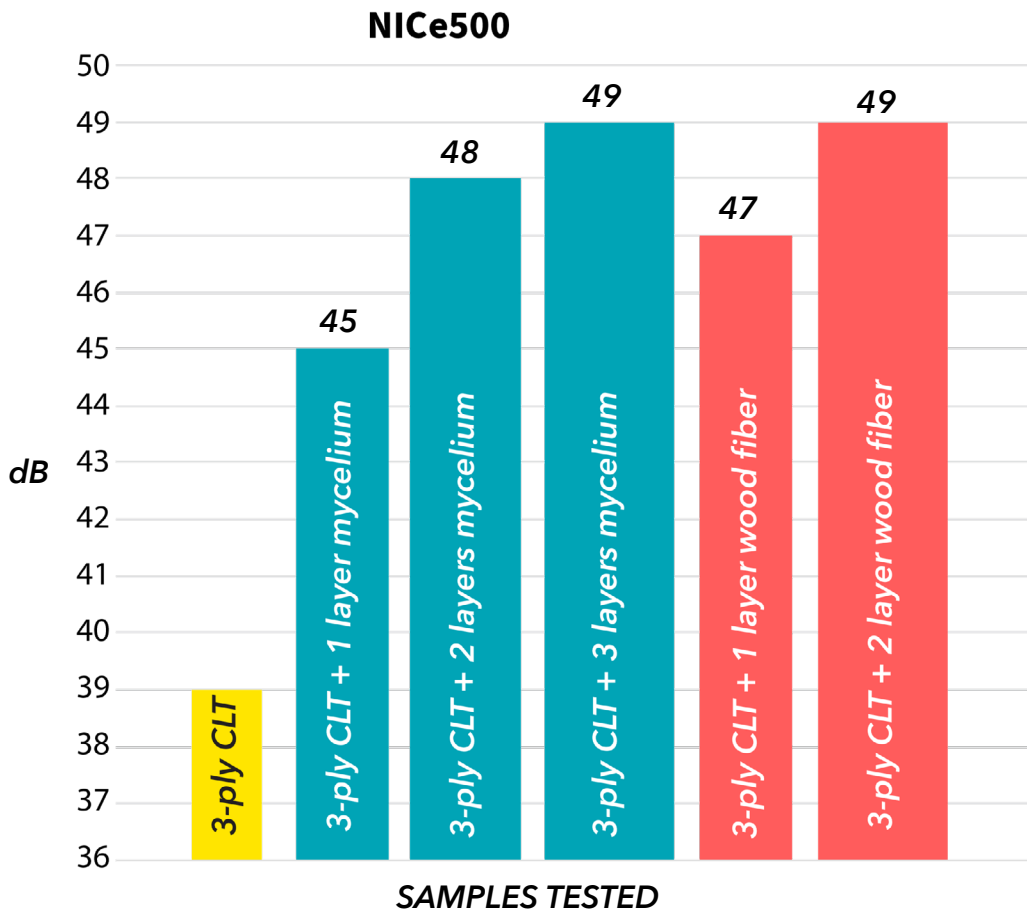
**1.5"
MYCELIUM**





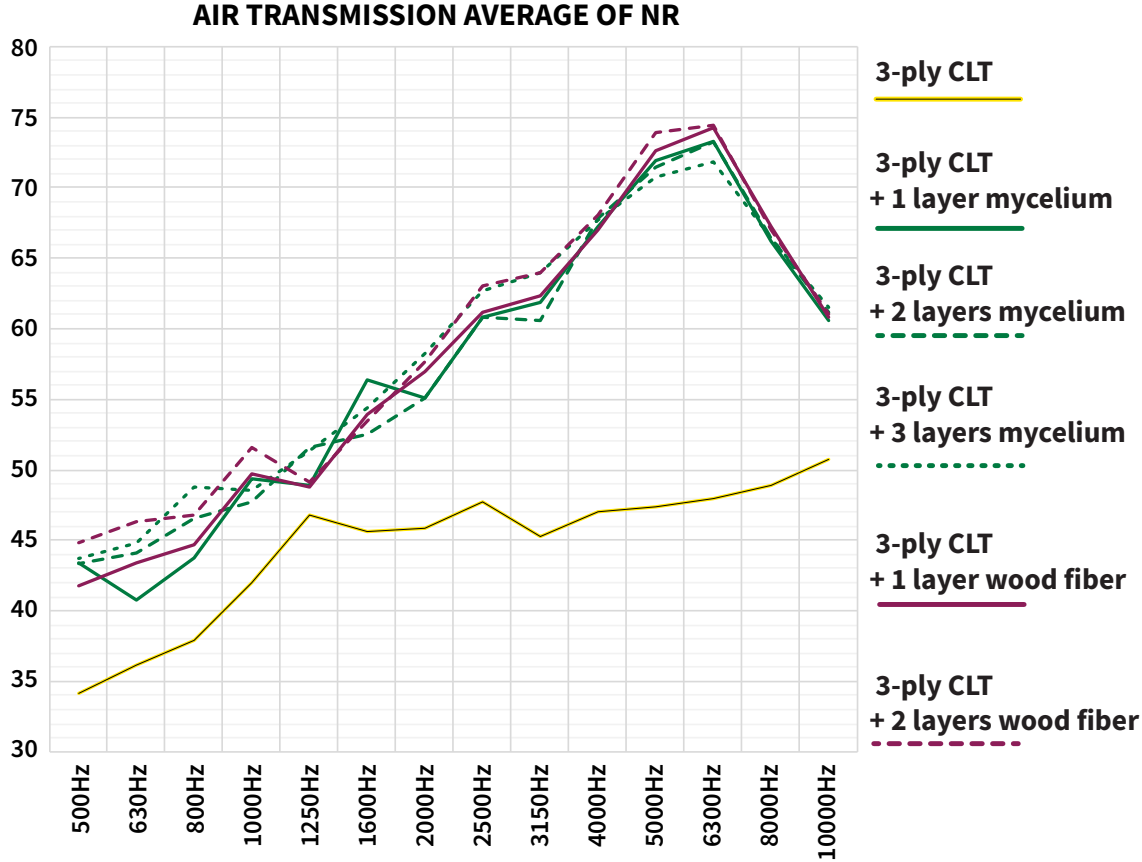
**2.0"
WOOD
FIBRE**

RESULTS



mycelium panels performed comparably to the dense wood fibre insulation despite being significantly less heavy

LIMITATIONS



there are *minor differences* between the performance of the mycelium panels and the wood fibre insulation

the chamber is not large enough for accurate low frequency testing

the mycelium panels were not always exactly 1.5"

there are many other non-biobased insulations we could have compared too but chose to compare against biobased.





EQUIPMENT

1.5” RIGID INSULATION

PLYWOOD

NAILS

2 x 2 SHIMMING

60W LIGHT BULB(HEAT SOURCE)

8 HOBO TEMPERATURE SENSORS

BOX CUTTER

RULER

T- SQUARE

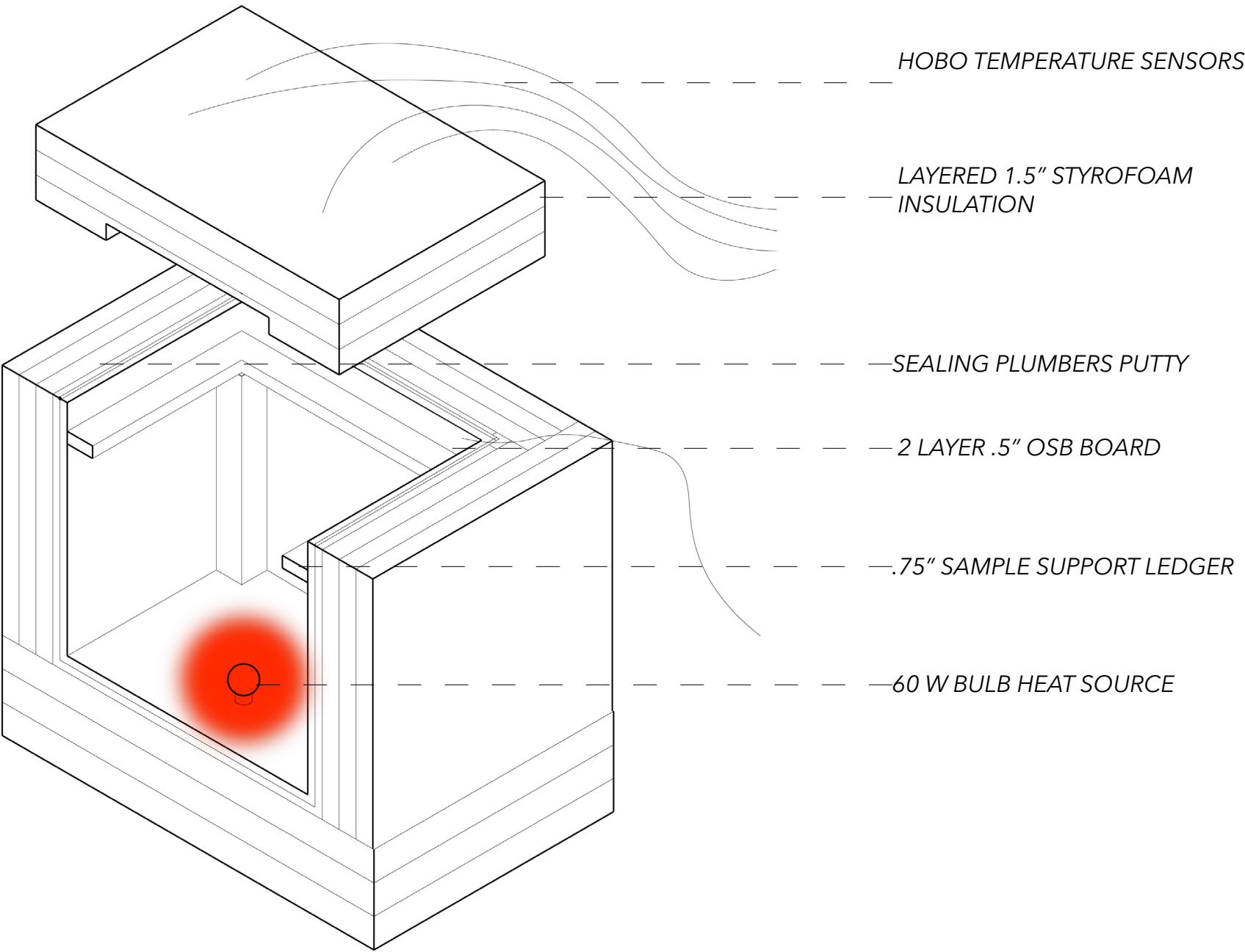
TABLE SAW

IMPACT DRIVER

PLUMBERS PUTTY

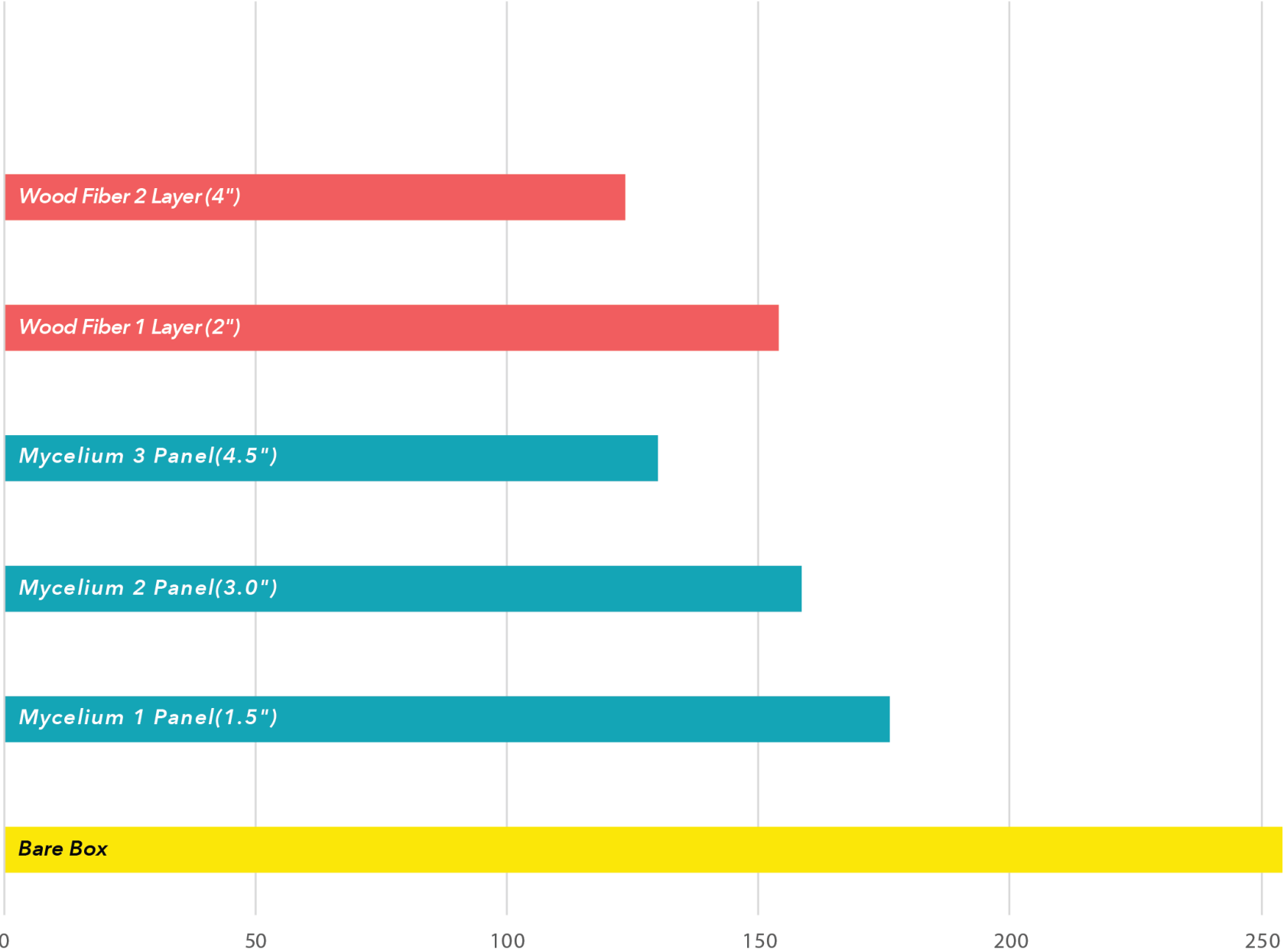
PROCESS-FABRICATION AND TESTING

1. CUT DOWN PLYWOOD MATCH THE SAMPLE SIZE YOU ARE TESTING
2. DOUBLE THE EXTERIOR WALLS AND BASE
3. USING THE 2X2 SHIMS, CREATE A BOX WITHOUT A LID
4. START CUTTING THE RIGID FOAM INSULATION TO COVER ALL SIDES OF THE BOX IN LAYERS OF 3
5. GLUE ALL PIECES TOGETHER
6. CREATE A 3 LAYER LID WITH A 12” X12” POCKET ON THE INSIDE OF THE LID FOR THE HOBO SENSORS TO FLOAT ABOVE THE SAMPLE
7. PLACE 4 HOBO SENSORS ON THE CORNERS
8. SEAL THE TOP WITH A PLYWOOD COVER AND SEAL ALL THE EDGES WITH PLUMBERS PUTTY SO THERE IS NO AIR LEAKAGE
9. INITIATE THE HOBO SENSORS TO START RECORDING AT THE SAME TIME USING HOBOWARE ON A LAPTOP
10. SET THE TEST TO RECORD EVERY 5 MINS FOR THE NEXT 24 HOURS AND END AFTER 24 HOURS
11. LET BOX RUN FOR 24 HOURS TO GET A BASELINE TEMP AND LOOK FOR CONSISTENT NUMBERS, THIS WILL INDICATE THE BASELINE TEMPERATURE OF THE BOX
12. OPEN YOUR BOX, REMOVE PLYWOOD AND REPLACE IT WITH YOUR TESTING SAMPLE(MYCELIUM ETC)
13. CONNECT TO YOUR HOBO SENSORS AND DOWNLOAD ALL THE DATA FROM THIS TEST INTO AN EXCEL SHEET
14. RESEAL THE BOX WITH THE LID AND RUN THE NEST TEST WITH THE SAME DATA LOGGING SET UP



RESULTS

THERMAL TEST RESULTS



LIMITATIONS

I do not have access to a calibrated thermal hot box which can cost a lot of money

area of tested sample varies from product information online(size tested). The company STEICO tests 4' x 8' panels

The Hotbox was made using ASTM as a guide and results may have differed if I chose another design such as a guarded box

CONCLUSIONS

This research demonstrates the potential for bio-based materials to significantly enhance the sustainability of mass timber wall assemblies, particularly within the context of the Pacific Northwest. By utilizing locally sourced materials such as wood fiber from invasive species and agricultural wastes bound with mycelium this study not only addresses regional ecological challenges but also promotes the development of sustainable, renewable building materials.

The testing of mycelium-based insulation panels, compared to commercialized bio-based materials, highlights the viability of these innovative solutions in providing effective thermal and acoustic insulation. The mass-to-sound insulation ratio of mycelium is far superior to that of wood fiber, demonstrating that even lab-made mycelium insulation can outperform commercially available alternatives. This finding underscores the practicality and effectiveness of mycelium-based materials in real-world applications.

The process of creating these mycelium panels is accessible and adaptable, enabling the production of high-performance insulation materials with minimal specialized equipment. This accessibility makes it feasible for local communities and small-scale producers to adopt and implement these sustainable practices, promoting widespread use and material autonomy.

The successful collaboration with the Material Composites Lab at Oregon State University underscores the importance of interdisciplinary partnerships in advancing sustainable construction technologies as seen in the production of the Juniper Panels.

The collaboration with the Energy Studies in Buildings Laboratory and their Micro Acoustic Chamber has been instrumental in validating the performance of the mycelium-based materials through acoustic testing. The replicable model developed in this research holds promise for application in other mass timber production regions such as Australia/New Zealand and Japan. By integrating traditional building practices; seen in Japan with Shou Sugi Ban and in Australia with sheep wool insulation; with modern sustainability principles, this study advocates for a resurgence of vernacular architecture that prioritizes locally sourced, renewable resources.

Ultimately, this research contributes to the broader goal of sustainable development in the construction industry. By fostering material autonomy and reducing reliance on non-renewable resources, the findings promote a shift towards more sustainable, environmentally responsible building practices. This work not only addresses contemporary sustainability challenges but also reconnects us with time-tested methods of construction, ensuring a more sustainable future for the built environment. By demonstrating the feasibility and advantages of bio-based materials, this research paves the way for innovative and sustainable solutions that can be adopted globally.

FUTURE RESEARCH

COMMERCIALISATION

Challenges of scaling up, costs of equipment, investment challenges but there is interest from companies like ForestConcepts in Auburn Washington who store and generate bio feed stocks and we have also been approach by people interested in this at the International Mass Timber Conference

VARIOUS SPAWN + SUBSTRATE TESTING

Testing the various mycelium spawns and agricultural waste stream combinations to find better strength and performance- time limitation

LIFE CYCLE ASSESSMENTS

Possibly doing LCA's to account for the carbon involved

ENVIRONMENTAL PRODUCT DECLARATIONS

Can we create this information? takes a while, maybe for a PhD

MATERIAL CATALOG
APPENDIX

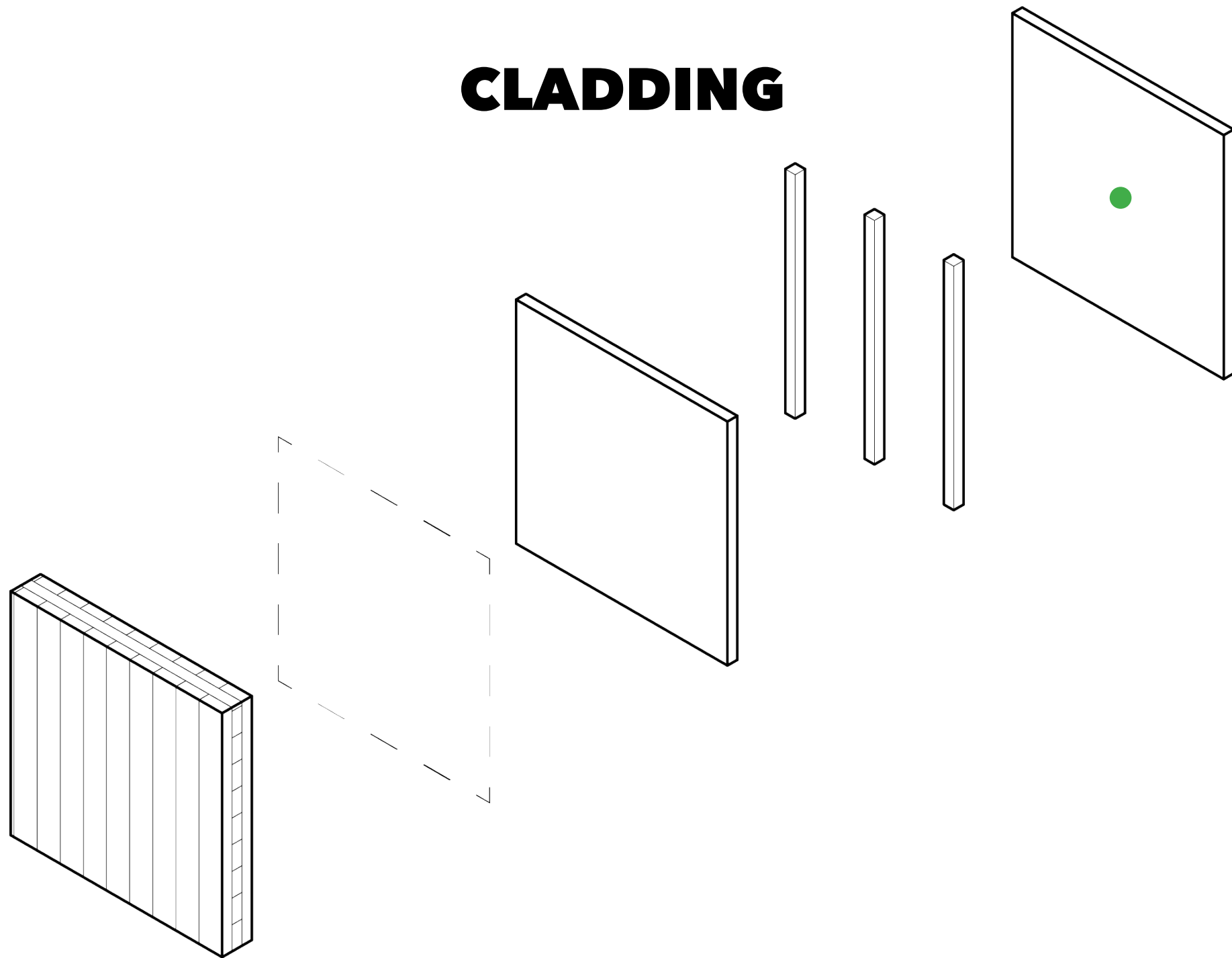


**JAPANESE
VERNACULAR
CLADDING AND
INSULATION**



Fig J1 Fig J2, J3, J4

CLADDING



SUGI: JAPANESE CEDAR



Fig J5, J6

Uncharred sugi siding, crafted from Japanese cedar (*Cryptomeria japonica*), is a highly regarded material for exterior applications due to its unique combination of physical and aesthetic properties. Sugi wood's density ranges from 0.38 to 0.45 g/cm³, making it lightweight yet robust enough for siding purposes (Wood Database) (Nakamoto Forestry). With a typical moisture content of 12% to 18%, it maintains moderate strength and dimensional stability, which helps prevent warping or shrinking under varying environmental conditions (Top Woodworking Advice).

One of the standout features of sugi wood is its natural durability. The wood contains oils and resins that make it resistant to decay, fungi, and insects, negating the need for chemical treatments (Nakamoto Forestry) (Nakamoto Forestry). This inherent resistance allows sugi siding to withstand harsh outdoor environments with minimal maintenance, making it a cost-effective and reliable option for exterior cladding.

Aesthetically, sugi wood is very appealing with its straight grain and distinctive reddish-brown hue. Over time, the wood weathers to a silvery gray, adding a rustic charm while maintaining its structural integrity (Nakamoto Forestry) (OLT). This aging process enhances the visual appeal of buildings over their lifespan.

In terms of workability, sugi is easy to cut, shape, and finish, allowing for precise and customized installations. This ease of handling reduces labor costs and time, making sugi a practical choice for various projects (Top Woodworking Advice). Additionally, it can be stained or sealed to further enhance its natural beauty and longevity (Nakamoto Forestry).

Sugi wood is also a sustainable material, often sourced from well-managed forests in Japan, supporting environmentally conscious building practices. Its long lifespan and minimal maintenance requirements contribute to a reduced environmental footprint over time (Nakamoto Forestry) (OLT).

In conclusion, uncharred sugi siding is an excellent choice for exterior applications due to its moderate strength, natural durability, aesthetic appeal, and sustainability. Its resistance to decay and pests, combined with its attractive aging process and ease of workability, makes it a preferred material for siding projects. As a renewable resource, sugi supports environmentally friendly building practices, ensuring that structures are both beautiful and built to last responsibly.



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CEDAR BARK



Cedar bark, particularly from Japanese cedar (sugi), is renowned for its distinctive texture and appearance, which make it a popular choice for various architectural and decorative applications. The fibrous texture and subtle color variations of cedar bark contribute to its rustic charm, giving structures a natural warmth and aesthetic appeal (Exploration Junkie) (Rare Woods USA).

Though not commonly used as a primary construction material, cedar bark holds significant value in decorative cladding. In Japan, cedar bark cladding is used to enhance the visual and cultural aspects of buildings, reflecting the traditional emphasis on harmony with nature. This practice is especially evident in traditional buildings and temples, where cedar bark cladding bridges modern structures with the natural environment (Ask IFAS - Powered by EDIS) (Rare Woods USA).

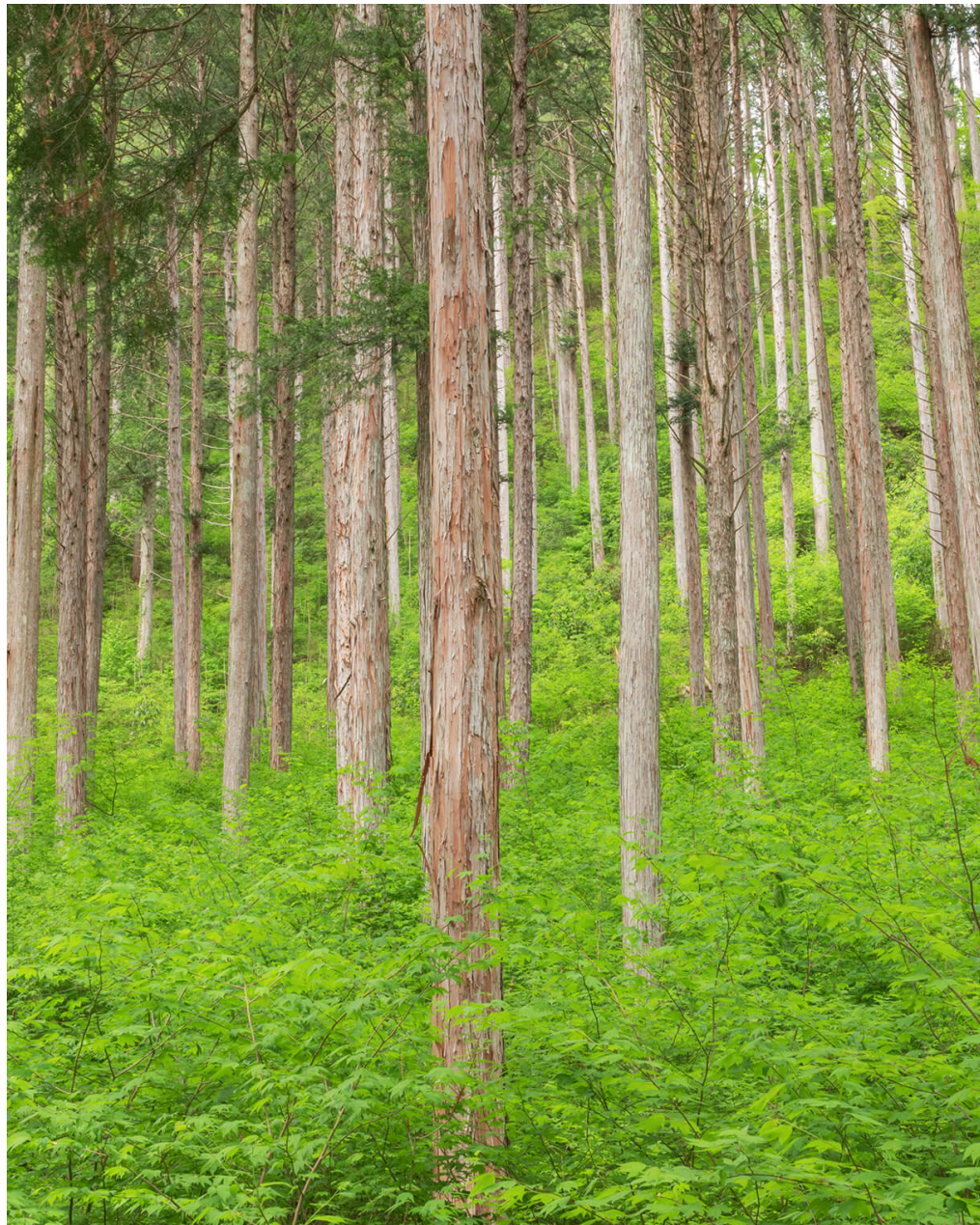
In Japanese craftsmanship, cedar bark is utilized to create a variety of woven products such as mats, baskets, and containers. This demonstrates the material's versatility and cultural heritage, showcasing the resourcefulness of traditional Japanese artisans. The craftsmanship involved in weaving cedar bark into functional and decorative items preserves techniques passed down through generations (MUSUBI KILN) (Rare Woods USA).

Regarding longevity, cedar bark harvested from young growth typically lasts about 20 years. It is marketed as 'maintenance-free,' meaning that after its functional lifespan, the bark can be removed and replaced. The removed bark is repurposed as mulch or winter fire fuel, aligning with sustainable practices and resourcefulness (Ask IFAS - Powered by EDIS) (Exploration Junkie).

The use of cedar bark in Japanese architecture and craftsmanship highlights a deep cultural and environmental consciousness. Its aesthetic qualities, traditional applications, and sustainable lifecycle contribute to its enduring appeal, enhancing the visual and cultural dimensions of Japanese architecture while supporting sustainability and natural harmony (MUSUBI KILN) (Moments Log) (Rare Woods USA).



HINOKI: JAPANESE CYPRESS



Hinoki siding offers a unique texture characterized by its fine grain and pale, aromatic wood, contributing to its serene aesthetic. The smooth surface and light coloration of hinoki wood enhance its visual appeal, making it a sought-after material for both traditional and modern architectural designs. This distinctive appearance is one of the reasons why hinoki wood is often used in high-end constructions and decor (The Slowdown, 2020; Tsukiita, 2020).

Hinoki wood is renowned for its natural resistance to decay, insects, and rot, making it an excellent choice for exterior siding. This durability is attributed to the high content of natural oils and resins in the wood, which provide long-lasting protection even in harsh environmental conditions. Historically, hinoki has been used in ancient Japanese temples and shrines, some of which have stood for over a thousand years, demonstrating its remarkable resilience (Japanmcconnell, 2020; Nagomi Japan, 2020).

One of the most distinctive features of hinoki siding is its pleasant aroma, released when the wood is cut or exposed to sunlight. This fragrance, which includes compounds like α -cadinol and α -pinene, adds to the sensory experience and acts as a natural insect repellent. The soothing scent of hinoki has been linked to relaxation and stress reduction, making it not only a practical choice but also beneficial for well-being (Japanmcconnell, 2020; Tsukiita, 2020; Nagomi Japan, 2020).

Hinoki holds significant cultural importance in Japan, associated with purity, tranquility, and longevity. Its use in traditional architecture, such as temples, shrines, and tea houses, underscores its spiritual and aesthetic significance. Hinoki wood symbolizes timeless elegance and a deep respect for nature, making it more than just a building material but a cultural emblem as well (The Slowdown, 2020; Japanmcconnell, 2020).



BAMBOO

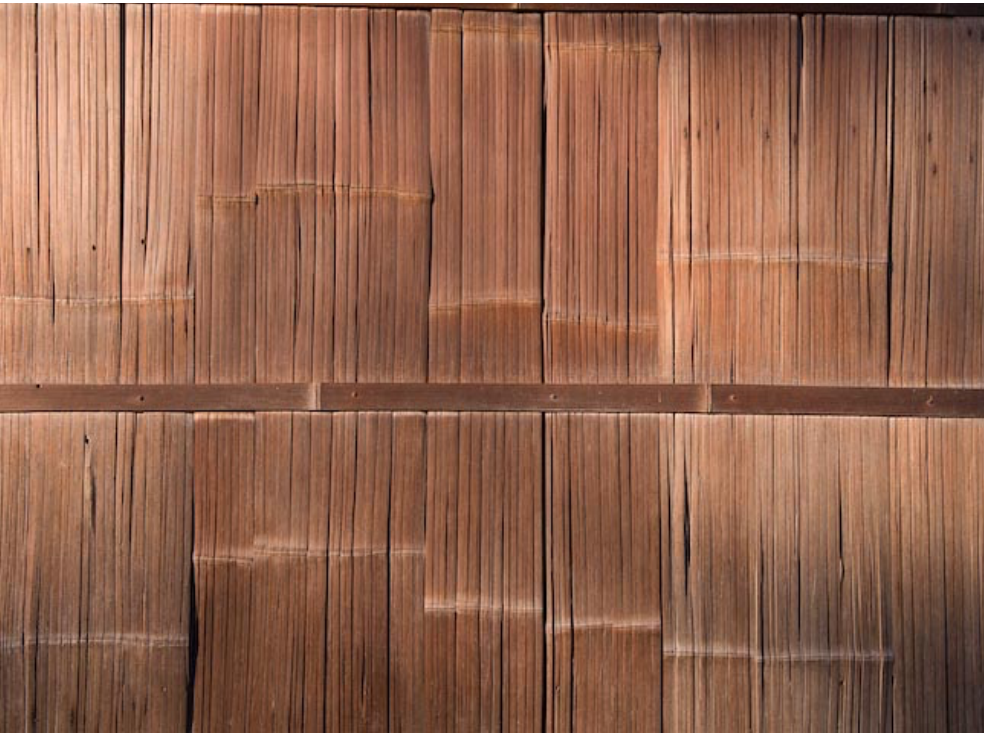


Bamboo cladding offers significant advantages in terms of thermal comfort and moisture resistance. Its natural insulation properties help maintain effective thermal regulation, making it a great choice for both hot and cold climates. Additionally, bamboo’s high resistance to moisture enhances its durability, even in humid environments, ensuring that it remains robust and long-lasting under various weather conditions (Building Renewable, 2024; Boo, 2024).

Bamboo is celebrated as a rapidly renewable and eco-friendly resource. It grows quickly, often maturing within two to five years, and its self-regenerating roots reduce soil erosion and maintain soil health. This makes bamboo an ideal material for sustainable construction practices. Moreover, its lightweight nature facilitates easy installation, reducing both construction time and labor costs. These properties make bamboo cladding a practical and environmentally responsible option for enhancing building exteriors (Building Renewable, 2024; The Constructor, 2024).

With minimal upkeep requirements and biodegradability at the end of its life cycle, bamboo cladding stands out as a low-maintenance choice that aligns with eco-friendly construction goals. Its sustainability is further enhanced by its capacity to absorb more carbon dioxide than many other plants, contributing positively to air quality and reducing the overall carbon footprint of building projects (Building Renewable, 2024; Boo, 2024). Beyond its pivotal role in construction, bamboo finds multifaceted applications in fencing, flooring, furniture craftsmanship, and various artistic endeavors. Its versatility is showcased in its use for creating durable and aesthetically pleasing products, from structural components to decorative items (The Constructor, 2024; Boo, 2024).

Enriching cultural traditions, bamboo holds profound significance in rituals such as tea ceremonies and vibrant festivities. It symbolizes strength and resilience, often being integrated into cultural practices that emphasize harmony with nature. This cultural relevance adds another layer of value to bamboo, making it not just a construction material but also a cultural icon (Building Renewable, 2024; Boo, 2024).



YAKISUGI



Shou Sugi Ban, a traditional Japanese method of wood preservation, involves charring cedar wood, which significantly enhances its resistance to insects, fire, and decay. This charring process creates a carbonized layer on the wood’s surface, which serves as a natural barrier against these elements. The result is a material that not only boasts increased durability but also features a stylish, weathered appearance that adds a unique aesthetic to various applications (Nakamoto Forestry, 2024; Woodthrive, 2024).

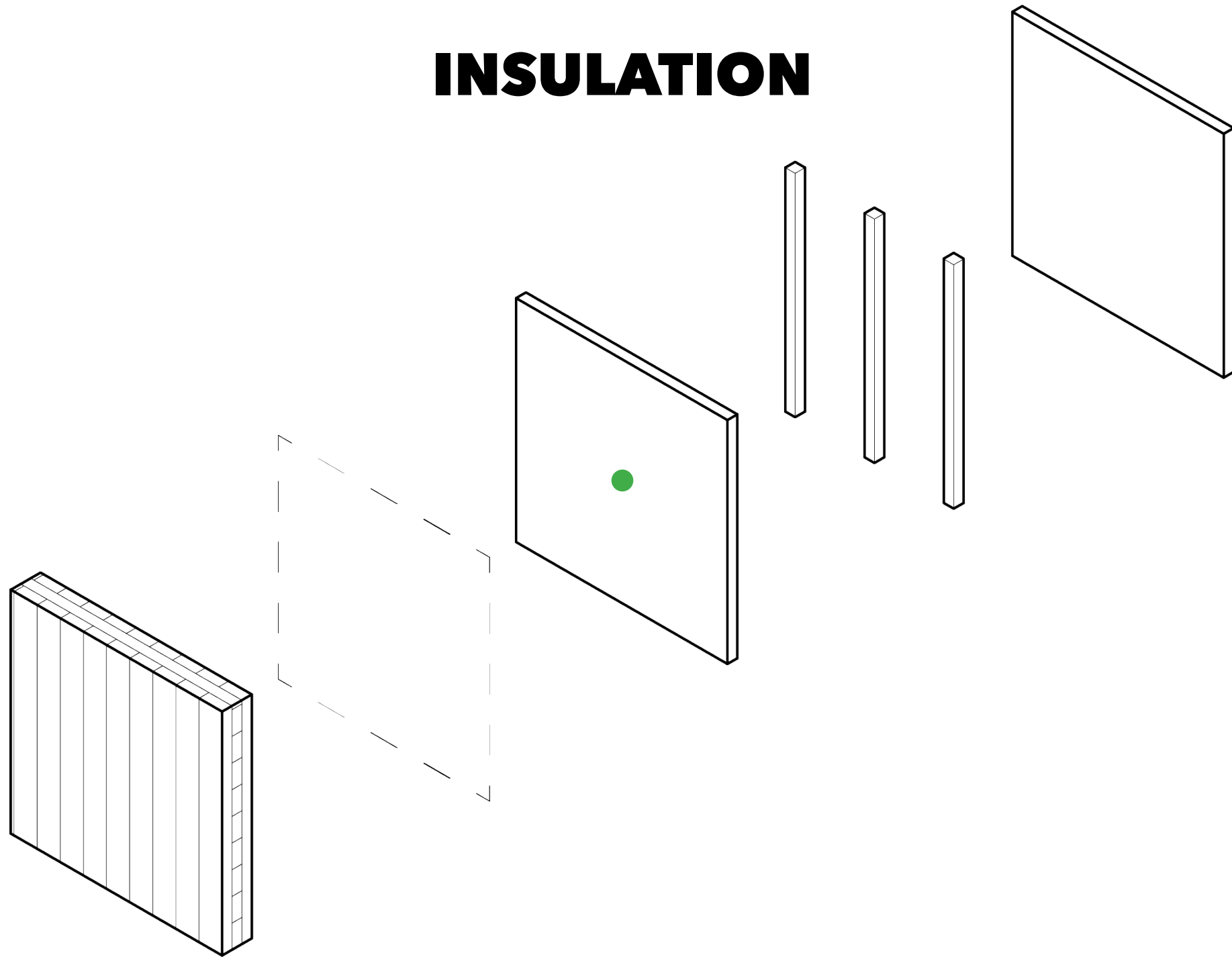
One of the notable benefits of Shou Sugi Ban is its longevity, with treated wood lasting up to 30 years with minimal maintenance. This durability makes it an excellent choice for exterior siding, fencing, and even interior design, where its distinctive look can enhance the visual appeal of any space (Build with Rise, 2024; Repaint Now, 2024).

Shou Sugi Ban also provides exceptional weather resistance. The charred layer offers excellent protection against UV radiation, rain, and temperature fluctuations, making it suitable for a wide range of climates. This weather resistance is complemented by the wood’s enhanced fire resistance. The charred surface slows down the spread of flames, as the carbon layer requires much higher temperatures to ignite compared to untreated wood, thereby enhancing safety in fire-prone areas (Nakamoto Forestry, 2024; Woodbeaver.net, 2024).

Moreover, Shou Sugi Ban is environmentally friendly. The process does not involve toxic chemicals, relying instead on natural methods to enhance the wood’s properties. This sustainable approach aligns well with eco-friendly construction practices, making Shou Sugi Ban a popular choice for those looking to minimize their environmental impact (Woodthrive, 2024; Build with Rise, 2024).



INSULATION



WASHI PAPER



Washi, crafted from Kozo fibers, is a sustainable alternative to wood-based papers. Kozo, a type of mulberry, grows rapidly, maturing in just 1-2 years, which significantly reduces its environmental impact compared to traditional wood-based paper sources that can take decades to mature. This makes washi a highly eco-friendly option (Superfolk, 2020; Foundland, 2020).

The Nagashizuki method, developed by Japanese papermakers, produces stronger, thinner, and semi-translucent papers by intricately intertwining fibers. This technique initially used gampi fibers, known for their slow drainage rate, which allowed for repeated movement of the pulp mixture over the screen, resulting in a stronger paper. However, due to the difficulty in cultivating gampi, papermakers adapted the process to use other plants that could provide the necessary viscous material (Superfolk, 2020).

Washi production involves meticulous handcrafting, with craftsmen employing the Nagashizuki method to continuously move fiber mixtures over screens. This process results in unique deckled edges and high-quality, durable paper. The dedication to this traditional method ensures each sheet of washi maintains its exceptional quality and distinctiveness (Jackson’s Art, 2020).

Japanese papermaking relies on specialized tools like the sukibune pulp vat and hinged moulds with flexible screens. These tools are integral to the distinctive techniques of the craft, allowing for the precise manipulation of fibers necessary to create the unique qualities of washi paper (Foundland, 2020).

The Fujimori family has preserved the tradition of Awagami washi papermaking for seven generations. Minoru Fujimori, recognized as an ‘Intangible Cultural Property of Tokushima,’ played a crucial role in maintaining this heritage. Today, the family continues this legacy under the leadership of Yoichi Fujimori, ensuring that the craft of washi making continues to thrive (Superfolk, 2020; Foundland, 2020).



BAMBOO FIBER



Processed bamboo fiber, used for insulation, incorporates the inherent benefits of natural bamboo stalks while offering enhanced functionality for building applications. This processed form of bamboo fiber provides exceptional thermal insulation due to its ability to form dense batts or sheets that trap air, minimizing heat transfer. This property is crucial for maintaining energy efficiency in buildings by keeping indoor temperatures stable throughout different seasons (Bambooyo, 2024).

In addition to thermal management, processed bamboo fiber excels in moisture resistance. Unlike traditional insulation materials that can absorb moisture and lead to mold growth, processed bamboo fiber naturally repels moisture. This resistance helps prevent mold and mildew in building environments, contributing to healthier indoor air quality (MDPI, 2024).

The sound absorption qualities of processed bamboo fiber are notable as well. The dense packing and unique fibrous structure of bamboo allow it to effectively dampen sound waves, reducing noise transmission between different areas of a building. This makes it ideal for use in multi-floor buildings or residential spaces where noise reduction is desired (Bambooyo, 2024).

As a rapidly renewable resource, bamboo grows back quickly after harvesting, making it a sustainable choice for insulation. The cultivation of bamboo requires minimal water, no pesticides, and no fertilizers, reducing its environmental footprint compared to traditional wood-based products. Furthermore, bamboo's growth rate is significantly faster than that of trees, providing a continuous supply for manufacturing without depleting resources (Bambooyo, 2024; MDPI, 2024).

Processed bamboo fiber is also celebrated for its non-toxic characteristics. It is free from harmful chemicals and low in volatile organic compounds (VOCs), ensuring it does not off-gas and compromise indoor air quality. This aspect is particularly important in green building practices, where maintaining a healthy indoor environment is paramount (MDPI, 2024).

The lightweight nature and flexibility of processed bamboo fiber make it easy to install. It can be cut and adjusted on-site to fit various spaces, simplifying the installation process and reducing labor costs. Moreover, its durability means it maintains its insulation properties over time, offering long-term savings and reducing the need for frequent replacements (Bambooyo, 2024; MDPI, 2024).



WARA: RICE STRAW



Wara rice straw insulation, rooted in Japanese agricultural traditions, is an excellent choice for sustainable and energy-efficient building projects due to its numerous beneficial properties.

Wara insulation provides effective thermal insulation, helping to regulate indoor temperatures and thus improving energy efficiency. The tubular structure of rice straw naturally traps air, minimizing heat transfer and maintaining stable indoor temperatures. This makes it highly effective for both traditional and modern Japanese homes, where energy efficiency is becoming increasingly important (MDPI, 2023).

Derived from rice straw, a byproduct of rice cultivation, Wara insulation is a renewable resource. In Japan, where rice farming is integral to the culture and economy, utilizing rice straw for insulation supports sustainable practices and reduces agricultural waste. This aligns with Japan's commitment to environmental sustainability and the promotion of a circular economy (MDPI, 2023).

Wara insulation also naturally repels moisture, preventing the growth of mold and mildew. This characteristic is particularly beneficial in Japan's humid climate, helping maintain indoor air quality and contributing to healthier living environments. The moisture resistance of rice straw ensures that it remains effective even in the varying weather conditions typical of Japan (ScienceDirect, 2023).

Additionally, its sound-absorbing qualities contribute to reducing noise transmission, enhancing acoustic comfort within buildings. The fibrous and tubular structure of rice straw effectively dampens sound waves, making it an ideal material for soundproofing. This is especially valuable in densely populated Japanese urban areas, where noise pollution can be a significant issue (BioResources, 2023).

The lightweight nature and ease of installation of Wara insulation make it suitable for various building applications in Japan. Its flexibility and ease of handling reduce labor costs and installation time, which is beneficial for both traditional Japanese architecture and modern construction methods. The material can be easily cut and fitted around obstacles, making it versatile for different construction needs (MDPI, 2023).

Wara rice straw insulation maintains its thermal and acoustic properties over time, ensuring long-lasting durability. This longevity contributes to cost-effectiveness and sustainability by reducing the need for frequent replacements. By providing a durable insulation solution, Wara insulation supports long-term energy savings and environmental benefits, aligning with Japan's sustainability goals (BioResources, 2023).



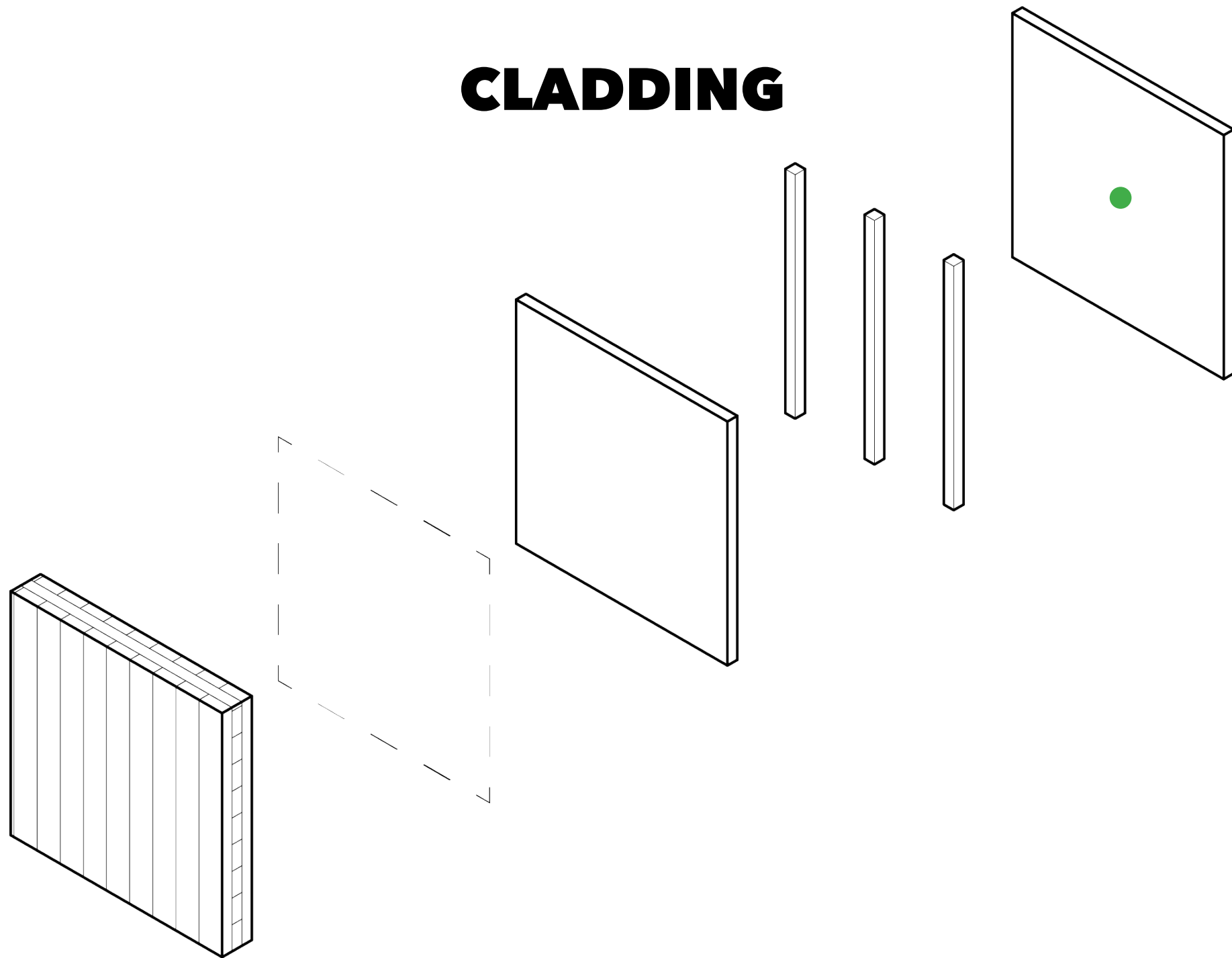
**AUSTRALIA/
NEW ZEALAND**



**AUSTRALIAN +
NEW ZEALAND
VERNACULAR
CLADDING AND
INSULATION**



CLADDING



CORK



Derived from the bark of cork oak trees, the harvesting process of cork is eco-friendly as it does not harm the trees. The bark regenerates every 9-12 years, making cork a renewable resource. This sustainable harvesting process contributes to cork's appeal as an environmentally friendly material for construction projects in both New Zealand and Australia (Building Renewable, 2024; Amorim Cork Composites, 2024).

Cork insulation provides excellent thermal insulation, helping to regulate indoor temperatures and thus improving energy efficiency. Its low thermal conductivity means it effectively traps heat, keeping homes warm in winter and cool in summer, which is particularly beneficial in the varying climates found across New Zealand and Australia (Building Renewable, 2024).

In addition to its thermal properties, cork is also highly effective at sound absorption. The material's cellular structure dampens sound waves, reducing noise transmission and enhancing acoustic comfort within buildings. This property is especially useful in urban areas where noise pollution is a concern (Diasen, 2023; Purgula, 2023).

Cork's water-resistant nature prevents moisture from penetrating, thereby inhibiting the growth of mold and mildew. This makes it a suitable choice for both interior and exterior applications in regions prone to humidity (Building Renewable, 2024; Amorim Cork Composites, 2024).

The material's lightweight and ease of installation further add to its advantages, making cork an appealing option for various building applications. It can be easily cut and fitted, reducing labor costs and installation time, which is beneficial for construction projects across New Zealand and Australia (Diasen, 2023; Building Renewable, 2024).

Beyond construction, cork is also used in various design applications, including flooring, wall coverings, and even in furniture and fashion accessories. Its natural texture and warmth add aesthetic value to interior spaces, making it a popular choice among designers and architects (Building Renewable, 2024).

Overall, cork insulation aligns well with sustainable building practices and offers a range of benefits that make it an ideal choice for eco-friendly construction projects in New Zealand and Australia.



EUCALYPTUS



Eucalyptus siding presents a sustainable option for exterior cladding, notable for its material properties and versatile applications in construction, particularly in Australia and New Zealand.

Derived from eucalyptus trees, which are abundant in these regions, this siding offers natural durability and resistance to weathering, making it well-suited for withstanding the harsh climates found in both countries. The material’s inherent toughness ensures it provides effective protection against moisture, UV radiation, and pests, thereby ensuring longevity and minimal maintenance requirements over time (Paneltec, 2023).

Eucalyptus siding contributes to sustainability efforts by utilizing renewable resources and promoting local sourcing practices. This aligns with the increasing emphasis on eco-friendly building materials in Australia and New Zealand, where sustainability is a significant concern in the construction industry (ArchiPro, 2023).

A key player in the field of sustainable building materials is Lignor, an Australian company known for its advanced engineered wood products. Lignor utilizes innovative stranding technology to produce high-performance materials from fast-growing, plantation-sourced eucalyptus and other woods. Their commitment to environmental sustainability includes the development of Cross Laminated Strand Timber (CLST®), a new patented product that provides superior strength and durability while supporting sustainable forestry practices. Lignor’s products are used in various applications, from residential housing to commercial and educational buildings, highlighting their versatility and performance in diverse construction projects (Lignor, 2023).

Incorporating eucalyptus siding into construction projects not only enhances the durability and aesthetic appeal of buildings but also supports local economies and sustainable forestry practices. This makes it an ideal choice for those looking to build or renovate homes and buildings in an environmentally responsible manner (Paneltec, 2023; ArchiPro, 2023).



WESTERN RED CEDAR



Western red cedar siding is a highly regarded choice for exterior cladding, prized for its exceptional material properties and versatile applications in construction, including in Australia. Sourced primarily from the Pacific Northwest region of North America, Western red cedar offers natural durability, longevity, and resistance to decay and insect infestation. This makes it particularly suitable for the diverse and often harsh climates found across Australia, where building materials must withstand significant weather variations (Tilling Timber, 2024; Timbeck, 2024).

The innate stability of Western red cedar allows it to endure fluctuating weather conditions without warping, shrinking, or swelling, which is crucial for maintaining the structural integrity and aesthetic appeal of buildings over time. This stability is a key reason for its popularity in both residential and commercial construction projects (Duffield Timber, 2024).

Western red cedar siding boasts a distinctive aesthetic appeal, characterized by its rich, reddish-brown tones and prominent grain patterns, which lend warmth and elegance to any architectural design. Its ability to age gracefully, developing a beautiful silver-gray patina if left untreated, adds to its charm and long-term appeal. This visual versatility makes it a favored material for architects and designers aiming to create both traditional and contemporary looks (Timbeck, 2024; Modinex, 2024).

In addition to its exterior applications, Western red cedar is also utilized in various interior applications, including paneling and trim work. This further enhances its use in construction projects, providing a consistent, high-quality material that can be used throughout a building's design (WoodPlank, 2024).

Overall, Western red cedar is not only a practical and durable choice but also a sustainable one. Its use supports environmentally friendly building practices, as it is a renewable resource that can be harvested responsibly. This sustainability aspect is increasingly important in today's construction industry, particularly in regions like Australia, where there is a strong emphasis on eco-friendly building materials (Tilling Timber, 2024; Modinex, 2024).



SPOTTED GUM



Spotted gum is a highly valued timber for exterior cladding in Australia due to its exceptional durability, natural beauty, and suitability for the local climate. As a native Australian hardwood, it is readily available and widely used in construction projects across the country. This timber is renowned for its high density, which ranges around 990 to 1010 kg/m³ when seasoned, and its excellent resistance to decay, moisture, and termite infestation, making it ideal for outdoor applications such as cladding, decking, and fencing (WoodSolutions, 2024; Business Queensland, 2024).

One of the standout features of spotted gum is its aesthetic appeal. It showcases a range of colors from pale browns to rich chocolate hues, often complemented by characteristic dark spots or veins. This natural variation adds significant visual interest and enhances the architectural appeal of buildings, making it a favored choice among architects and homeowners alike (Austimber, 2024).

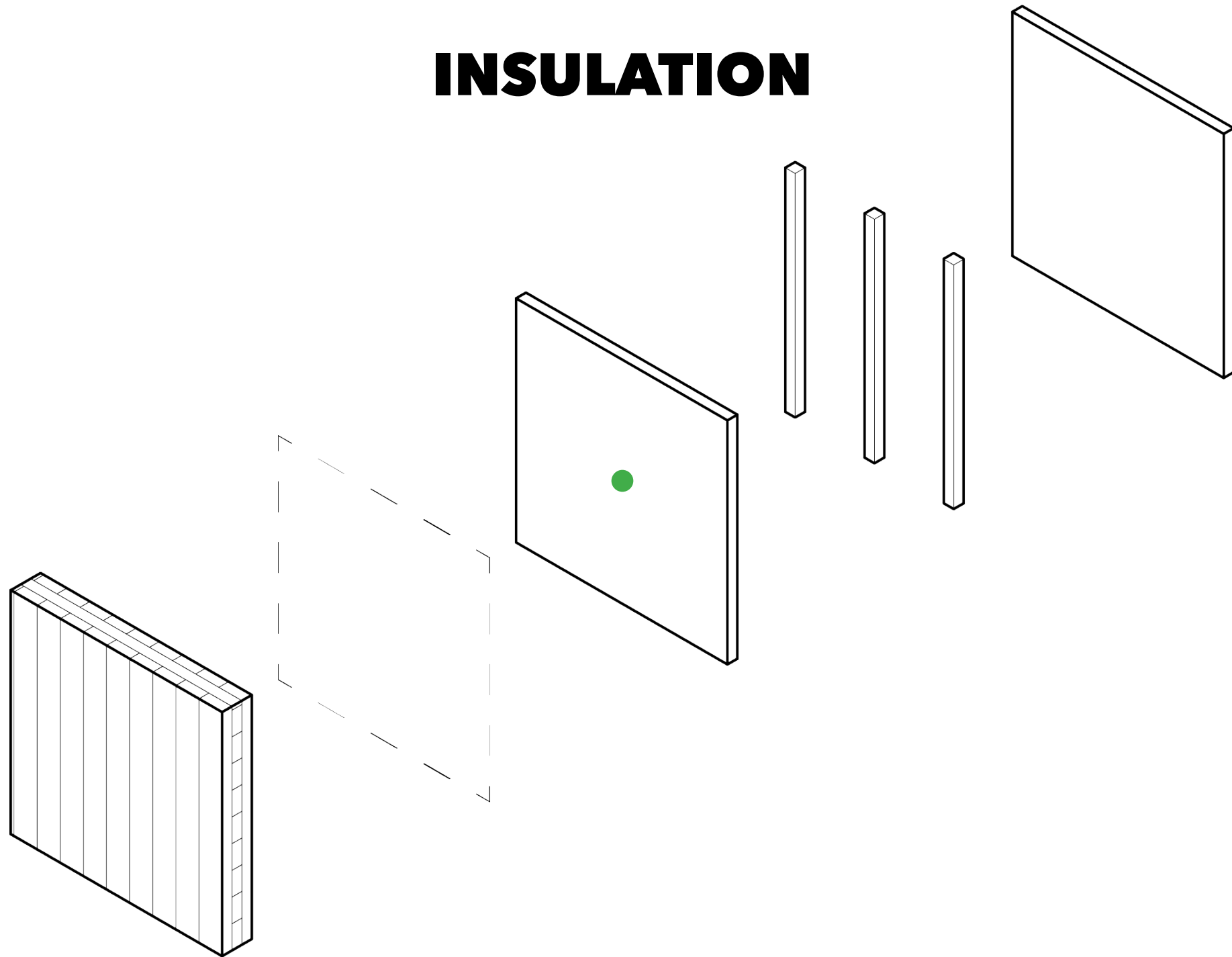
In terms of mechanical properties, spotted gum exhibits impressive strength and stability. It has a high Janka hardness rating of about 11.0 kN and a modulus of rupture of 142 MPa when seasoned, which makes it highly resistant to wear and able to withstand heavy foot traffic. Additionally, its interlocking grain structure provides excellent dimensional stability, reducing the risk of warping or twisting, even when exposed to varying moisture levels (Wood Database, 2024; Kennedy's Timbers, 2024).

Spotted gum is also known for its ease of machining due to its naturally greasy texture, which allows for smooth processing and precise installation. This makes it suitable for a variety of design options, extending beyond exterior cladding to include interior applications such as flooring, paneling, and joinery (Mortlock Timber, 2024).

Furthermore, spotted gum supports sustainable construction practices. It is harvested from well-managed forests, ensuring a renewable supply while minimizing environmental impact. Its natural fire resistance also makes it suitable for use in bushfire-prone areas, providing an added layer of safety (Business Queensland, 2024; Austimber, 2024)



INSULATION



SHEEP'S WOOL



Sheep wool insulation is a sustainable and effective choice for both residential and commercial construction projects in Australia and New Zealand. Its natural properties, including thermal resistance and fire resistance, make it ideal for regulating indoor temperatures and enhancing safety.

Sheep wool insulation provides excellent thermal insulation, with an R-value of 3.5 to 3.8 per inch, making it comparable to traditional insulation materials. Its ability to maintain thermal resistance even when absorbing moisture sets it apart from other insulators like mineral wool, which can lose its effectiveness when wet. The unique structure of wool fibers allows it to absorb up to a third of its weight in moisture without losing its insulating properties, which helps in controlling humidity and preventing mold growth (Green Coast, 2024; Bob Vila, 2024).

In addition to thermal properties, sheep wool insulation is also fire-resistant. Its natural high nitrogen content makes it self-extinguishing, and when treated with fire retardants like boric acid, it becomes even more resistant to flames. This makes it a safe choice for insulation, reducing the risk of fire spread within buildings (Pricewise Insulation, 2024; Building Renewable, 2024).

Sourced sustainably, sheep wool insulation reduces environmental impact. The wool used is typically a byproduct of the sheep farming industry, which means that its use helps in reducing waste. Additionally, the energy required to produce wool insulation is significantly lower compared to synthetic materials. This contributes to a lower carbon footprint, aligning with sustainable building practices (Wool Insulation NZ, 2024; Bob Vila, 2024).

Sheep wool insulation is also durable and long-lasting. The elasticity of wool fibers ensures that the insulation remains effective over many years, maintaining its shape and insulating properties without significant degradation. This durability reduces the need for frequent replacements, offering long-term cost benefits (Green Coast, 2024).



SHREDDED PAPER/ CELLULOSE



Cellulose insulation is gaining recognition for its effectiveness and sustainability. Crafted from recycled paper, cellulose insulation provides efficient thermal insulation, helping to maintain comfortable indoor temperatures and reduce energy consumption. This makes it particularly useful for both residential and commercial buildings, especially when used in walls and ceilings.

When installed in walls, cellulose insulation creates a barrier against heat transfer, enhancing energy efficiency and occupant comfort. Dense-pack cellulose insulation, which involves blowing the material into wall cavities, ensures it fills all gaps around pipes and wiring, preventing air pockets and minimizing heat loss (Roo Roofing, 2024; BUILD, 2024). This method is particularly effective in maintaining a stable indoor temperature.

In ceilings, cellulose insulation effectively prevents heat loss during colder months and heat gain in warmer seasons, contributing to overall energy savings. Its high thermal resistance ensures homes remain warm in winter and cool in summer, reducing reliance on heating and cooling systems and thus lowering energy bills (Insul Fibre, 2024; Building Performance, 2024).

Cellulose insulation also excels in soundproofing. Its dense composition reduces noise transmission, creating a quieter and more peaceful indoor environment. This is particularly beneficial in urban areas or multi-occupant buildings where noise reduction is crucial (Natural Insulation, 2024; BUILD, 2024).

Moreover, cellulose insulation is environmentally friendly. Made primarily from recycled newspaper, it helps reduce landfill waste and the demand for new raw materials. Its production and installation have a lower environmental impact compared to traditional insulation materials like fiberglass and foam (Roo Roofing, 2024; Insul Fibre, 2024).



CORK



Derived from the bark of cork oak trees, the harvesting process of cork is eco-friendly as it does not harm the trees. The bark regenerates every 9-12 years, making cork a renewable resource. This sustainable harvesting process contributes to cork's appeal as an environmentally friendly material for construction projects in both New Zealand and Australia (Building Renewable, 2024; Amorim Cork Composites, 2024).

Cork insulation provides excellent thermal insulation, helping to regulate indoor temperatures and thus improving energy efficiency. Its low thermal conductivity means it effectively traps heat, keeping homes warm in winter and cool in summer, which is particularly beneficial in the varying climates found across New Zealand and Australia (Building Renewable, 2024).

In addition to its thermal properties, cork is also highly effective at sound absorption. The material's cellular structure dampens sound waves, reducing noise transmission and enhancing acoustic comfort within buildings. This property is especially useful in urban areas where noise pollution is a concern (Diasen, 2023; Purgula, 2023).

The material's lightweight and ease of installation further add to its advantages, making cork an appealing option for various building applications. It can be easily cut and fitted, reducing labor costs and installation time, which is beneficial for construction projects across New Zealand and Australia (Diasen, 2023; Building Renewable, 2024).

Beyond construction, cork is also used in various design applications, including flooring, wall coverings, and even in furniture and fashion accessories. Its natural texture and warmth add aesthetic value to interior spaces, making it a popular choice among designers and architects (Building Renewable, 2024).

Overall, cork insulation aligns well with sustainable building practices and offers a range of benefits that make it an ideal choice for eco-friendly construction projects in New Zealand and Australia.



HEMP



Hemp cultivation is recognized for its minimal water requirements and lack of pesticide use, contributing to its reputation as an environmentally friendly crop. In Australia and New Zealand, hemp fiber insulation is gaining popularity due to its excellent thermal and acoustic properties. This natural material not only helps regulate indoor temperatures but also dampens sound, enhancing comfort and reducing energy consumption in buildings.

Hemp fiber insulation boasts impressive thermal resistance, with an R-value that can compete with traditional insulation materials like fiberglass and cellulose. The structure of hemp fibers allows them to trap air effectively, providing a robust barrier against heat transfer. This property ensures that homes remain warm in the winter and cool in the summer, reducing the need for artificial heating and cooling (Australian Hemp Council, 2024; Hemp Block Australia, 2024).

One of the standout benefits of hemp insulation is its mold resistance. Hemp fibers naturally resist mold and mildew, which is crucial for maintaining indoor air quality. This resistance is due to the material's ability to absorb and release moisture, preventing the conditions that typically promote mold growth. This makes hemp insulation particularly suitable for regions with high humidity or buildings prone to dampness (OzHemp, 2024; Kohu Hemp, 2024).

Furthermore, hemp insulation is non-toxic and does not off-gas harmful chemicals, unlike some synthetic insulation materials. This characteristic makes it a healthier choice for indoor environments, contributing to better overall air quality and reducing potential health risks associated with exposure to volatile organic compounds (VOCs) (Hemp Block Australia, 2024).

In addition to its use in insulation, hemp fibers are utilized in various other products, highlighting their versatility. These include textiles for clothing, ropes, and even composite materials used in construction. One notable application is hempcrete, a biocomposite material made from hemp hurds and lime. Hempcrete is lightweight, breathable, and provides excellent thermal insulation. It is used for constructing walls and floors, offering an eco-friendly alternative to traditional concrete (Kohu Hemp, 2024; OzHemp, 2024).

Hemp insulation supports sustainable construction practices by using a renewable resource that can be grown quickly and sustainably. The cultivation of hemp helps sequester carbon dioxide, contributing to the reduction of greenhouse gases in the atmosphere. This aspect, combined with its energy-saving properties, makes hemp insulation a highly sustainable choice for modern building projects (Australian Hemp Council, 2024; Hemp Block Australia, 2024).



STRAW BALE



Straw bale construction is gaining popularity in Australia due to its sustainability, excellent thermal efficiency, and versatility in design. Harvested from cereal crops such as wheat, barley, or rice, straw bales utilize agricultural by-products that would otherwise be discarded, promoting eco-friendly practices and reducing the carbon footprint associated with conventional building materials. Using these agricultural by-products helps prevent waste and contributes to environmental conservation (ArchDaily, 2024; Australian Design Review, 2024).

Straw bale construction offers significant thermal efficiency. Straw has a low thermal conductivity, making it an excellent insulator. This quality helps maintain comfortable indoor temperatures, keeping buildings cool in summer and warm in winter, and reducing the reliance on artificial heating and cooling systems. Well-built straw bale houses can save up to 75% in heating and cooling costs, making them highly energy-efficient. The thermal conductivity of straw is comparable to expanded polystyrene, further enhancing its insulating properties (ArchDaily, 2024; Australasian Straw Bale Building Association, 2024).

Despite common misconceptions, straw bale construction is highly fire-resistant. When straw bales are tightly packed and covered with plaster, they create an airless environment that significantly reduces the risk of combustion, similar to trying to ignite a phone book. Properly constructed and rendered straw bale walls have been shown to meet fire safety standards, including those required for bushfire-prone areas in Australia.

The tightly packed bales and protective renders prevent oxygen from feeding potential fires, making straw bale structures safe and compliant with stringent fire safety regulations (Australasian Straw Bale Building Association, 2024). Straw bale construction is versatile in terms of design, accommodating curves and organic shapes with ease. This flexibility extends to various construction techniques, including load-bearing and non-load-bearing systems, as well as hybrid approaches that combine elements of both. The post-and-beam method, for instance, uses a wooden or steel frame to support the structure, with straw bales serving as insulation infill. This versatility allows for creative and aesthetically pleasing architectural designs (Australian Design Review, 2024).

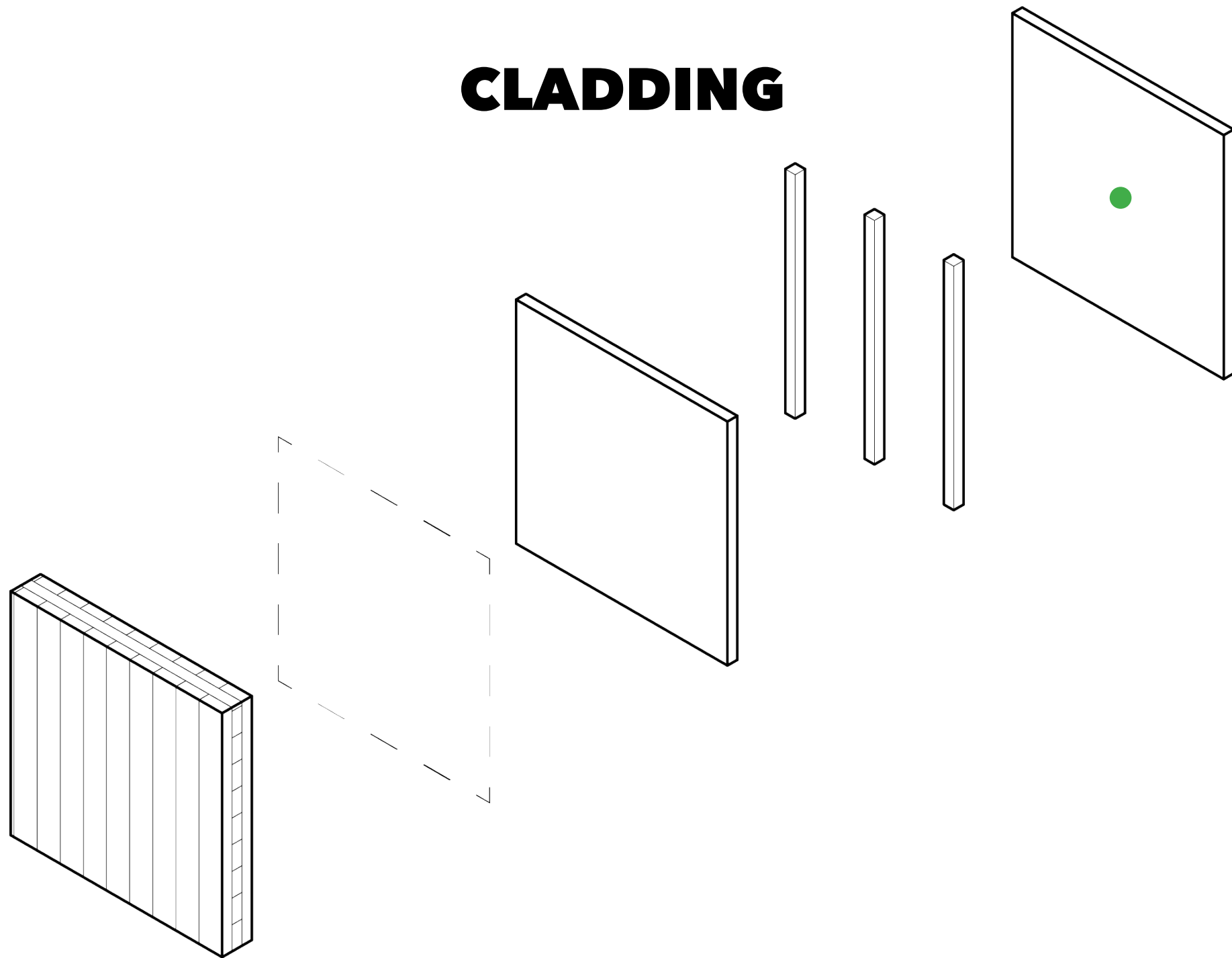
In addition to its thermal and fire-resistant properties, straw bale construction offers significant health and environmental benefits. The walls are breathable, allowing for natural air circulation without moisture penetration, which helps prevent the growth of mold and improves indoor air quality. This breathability is crucial in mitigating issues like 'sick building syndrome,' where poor ventilation and dampness can lead to health problems. The use of natural and non-toxic materials in straw bale construction further enhances its health benefits, creating healthier living environments (Australian Design Review, 2024).



**PACIFIC
NORTHWEST**



CLADDING



WESTERN RED CEDAR



Western red cedar is renowned for its exceptional properties, making it a top choice for construction projects in the Pacific Northwest. This species is highly resistant to decay, insects, and moisture due to its production of thujaplicins, natural fungicidal compounds. These compounds give Western red cedar its remarkable durability, enabling it to thrive in outdoor applications such as siding, decking, and fencing without requiring chemical treatments (Naturally Wood, 2024; Duffield Timber, 2024).

The wood's aesthetic qualities are equally impressive. Western red cedar features a straight grain and uniform texture, contributing to its timeless elegance. Its color palette ranges from rich reddish-brown to salmon pink and chocolate brown streaks, which add visual interest and charm. Over time, untreated cedar gracefully weathers to a silver-grey patina, maintaining its aesthetic appeal even as it ages (Evergreen Adventures PNW, 2024; Duffield Timber, 2024).

Western red cedar is also lightweight, which simplifies handling and installation. Its low density not only makes it easier to work with but also enhances its thermal and acoustic insulation properties. The wood's structure contains air spaces within its cells, which provide good insulation against temperature extremes and sound. This characteristic is beneficial for maintaining comfortable indoor environments and reducing energy consumption (Duffield Timber, 2024).

Moreover, Western red cedar's stability is a significant advantage in construction. The wood exhibits minimal shrinkage and swelling in response to moisture changes, reducing the risk of warping, cupping, and twisting. This dimensional stability ensures that cedar products retain their shape and integrity throughout their service life, making them ideal for exterior applications exposed to varying weather conditions (Naturally Wood, 2024).

The versatility of Western red cedar extends to both its use and workability. It is easily planed and shaped, can be sanded to a smooth finish, and accepts a variety of finishes and treatments well. The wood glues easily, has moderate nail and screw holding ability, and can be machined with sharp tools to produce a satiny finish. However, it is essential to use stainless steel or corrosion-resistant fasteners, as the natural tannins in cedar can react with iron, causing staining (Duffield Timber, 2024; Naturally Wood, 2024).





Adobe construction in the Pacific Northwest combines sustainability with impressive thermal and acoustic insulation properties, making it a valuable choice for eco-friendly building projects. Adobe is crafted from a mixture of clay, sand, and straw, which are locally sourced, reducing the environmental impact associated with transportation and material processing (ArchiPro, 2024; Homeshift Team, 2024).

Adobe bricks offer excellent thermal mass, meaning they can absorb heat during the day and release it slowly at night. This helps maintain stable indoor temperatures, reducing the need for artificial heating and cooling systems. Despite adobe’s relatively low R-value, its significant thermal mass allows it to perform effectively as an insulator in various climates, including the Pacific Northwest (Science Alert, 2024; MDPI, 2024).

The material is also known for its ability to regulate indoor humidity. The unfired clay in adobe acts as a natural dehumidifier, absorbing excess moisture from the air and releasing it when needed. This property helps prevent condensation and mold growth, contributing to healthier indoor environments, which is particularly beneficial in the humid conditions often found in this region (ArchiPro, 2024).

In addition to its thermal and moisture-regulating properties, adobe provides sound insulation, dampening noise and creating a quieter living space. This makes it an ideal material for both urban and rural settings, where noise reduction can significantly enhance comfort (Science Alert, 2024).

Modern innovations in adobe construction, such as the development of low-density adobe bricks, have improved its insulation capabilities. These advancements combine traditional building techniques with modern materials like wood shavings and recycled paper cellulose, resulting in bricks that meet current insulation standards while retaining the aesthetic and structural benefits of traditional adobe (ArchiPro, 2024).





Cob construction is a sustainable building method gaining traction in the Pacific Northwest due to its eco-friendly nature, thermal properties, and unique aesthetic appeal. Cob, a mixture of clay, sand, and straw, is an ancient building material that has been used world-wide for centuries. This method offers several advantages, particularly in terms of sustainability and thermal mass.

Cob homes are highly energy-efficient due to their significant thermal mass. The thick walls of a cob house can absorb heat during the day and release it slowly at night, maintaining stable indoor temperatures and reducing the need for additional heating and cooling. This property makes cob an ideal material for regions with large temperature fluctuations between day and night (This Cob House, 2024; Off Grid World, 2024).

One of the primary benefits of cob construction is its sustainability. Most of the materials used in cob buildings can be sourced locally, often directly from the building site. This reduces transportation emissions and the overall carbon footprint of the construction process. Additionally, cob uses renewable and biodegradable materials, aligning with environmentally conscious building practices (Off Grid World, 2024; Natural Building Alliance, 2024).

Cob walls also offer excellent sound insulation due to their density and thickness, creating a quieter indoor environment. The hygroscopic nature of cob helps regulate indoor humidity levels by absorbing and releasing moisture as needed, which improves indoor air quality and prevents mold growth (Natural Building Alliance, 2024).

Cob walls also offer excellent sound insulation due to their density and thickness, creating a quieter indoor environment. The hygroscopic nature of cob helps regulate indoor humidity levels by absorbing and releasing moisture as needed, which improves indoor air quality and prevents mold growth (Natural Building Alliance, 2024).

Despite these advantages, cob construction does have some limitations. Building with cob is labor-intensive and time-consuming, as each layer must dry before the next one is applied. This process can take months or even years, depending on the size of the structure and the climate. Additionally, cob homes require regular maintenance to prevent water damage, particularly in wet climates. Proper design elements, such as wide roof overhangs and good drainage, are essential to protect cob walls from excessive moisture (Off Grid World, 2024).

Cob construction also faces challenges with building codes and permits in some areas. Although recent efforts have led to the adoption of cob building standards in the International Residential Code (IRC), some jurisdictions may still require additional documentation or engineering assessments to ensure compliance with local regulations, particularly in seismic regions (Natural Building Alliance, 2024).



STONE VENEER



One of the primary benefits of stone veneer is its ability to resist harsh weather conditions, including extreme temperatures, humidity, rain, and UV exposure. This resilience is a result of high-quality manufacturing processes that infuse the veneer with properties capable of withstanding environmental stresses while maintaining its structural integrity and visual appeal over many years (Evolve Stone, 2024; Stoneyard, 2024).

Stone veneer is significantly lighter than natural stone, which offers several practical advantages. Its reduced weight lowers transportation costs and simplifies installation, often eliminating the need for heavy machinery and extensive labor. This makes stone veneer a cost-effective solution for both new constructions and renovations. The ease of handling also means that installation can be completed more quickly and with fewer workers, further reducing labor costs (Evolve Stone, 2024; Stoneyard, 2024).

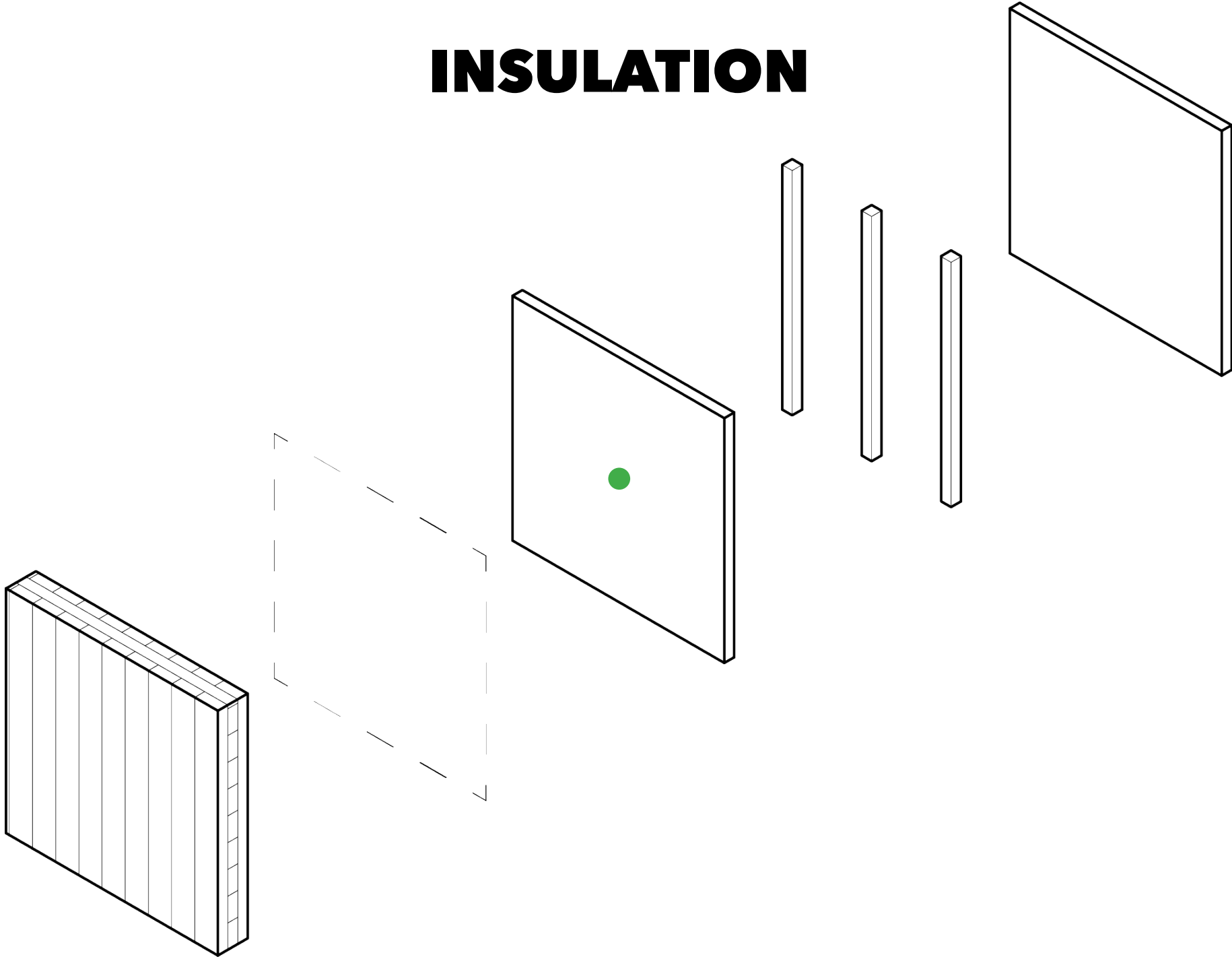
In terms of aesthetics, stone veneer provides the luxurious look of natural stone at a fraction of the cost. Available in a variety of styles, colors, and textures, stone veneer can mimic the appearance of quarried stone, enabling designers and builders to achieve a high-end look without the associated expense. This versatility allows it to blend seamlessly with both traditional and contemporary architectural styles, enhancing the visual appeal of homes and commercial buildings alike (Evolve Stone, 2024; This Old House, 2024).

Stone veneer also contributes to energy efficiency. Its thermal mass properties help regulate indoor temperatures by retaining heat during the day and releasing it at night, reducing the need for additional heating and cooling. This can result in significant energy savings over time, making stone veneer not only a visually appealing choice but also a practical one for improving energy efficiency (Stoneyard, 2024).

Moreover, stone veneer requires minimal maintenance. Routine cleaning with mild detergent and water is usually sufficient to keep it looking its best, and it is less susceptible to issues like mold and decay compared to other materials. This low maintenance requirement translates to long-term cost savings and ensures that the veneer remains attractive and functional for years (Evolve Stone, 2024; Stoneyard, 2024).



INSULATION



HEMP



Hemp insulation is becoming an increasingly attractive option in Oregon due to its sustainable properties, excellent thermal efficiency, and positive environmental impact. Sourced from the fibers of hemp plants, this insulation material is not only renewable but also contributes to carbon sequestration, reducing the overall carbon footprint of buildings (Project: My Green Planet, 2024; Energy.gov, 2024).

Hemp insulation offers impressive thermal resistance, with an R-value of approximately 3.7 per inch of thickness. This makes it comparable to traditional insulation materials such as fiberglass and mineral wool. Its high density also provides effective acoustic insulation, dampening noise and creating a quieter indoor environment (Material Warehouse, 2024; Project: My Green Planet, 2024).

One of the significant advantages of hemp insulation is its ability to regulate moisture. Hemp fibers can absorb and release moisture without losing their insulating properties, which helps maintain a stable indoor humidity level and prevents mold growth. This characteristic contributes to healthier indoor air quality and enhances the durability of the building structure (Energy.gov, 2024).

Additionally, hemp insulation is non-toxic and does not off-gas harmful chemicals, unlike some synthetic insulation materials. This makes it safer for installers and occupants, reducing health risks associated with respiratory issues and skin irritation commonly linked to traditional insulation products (Material Warehouse, 2024).

In terms of sustainability, hemp grows rapidly and requires minimal pesticides and water, making it an eco-friendly crop. The use of hemp in insulation helps reduce waste and supports agricultural sustainability. Furthermore, the production process for hemp insulation has a lower environmental impact compared to conventional insulation materials, aligning with Oregon’s commitment to green building practices (Energy.gov, 2024; Project: My Green Planet, 2024).

Overall, hemp insulation provides a robust, eco-friendly, and health-conscious alternative for building projects in Oregon. Its combination of thermal efficiency, moisture regulation, and sustainability makes it a valuable material for both residential and commercial construction.



WOOD FIBER



Wood fiber insulation is gaining popularity in Oregon due to its sustainable properties, thermal efficiency, and versatility. This type of insulation is made from wood by-products like sawdust, chips, and off-cuts from the sawmill industry, which are processed into fibrous materials used to create boards or flexible quilts (Home-building, 2024).

One of the primary benefits of wood fiber insulation is its excellent thermal properties. It has a high thermal mass, which means it can absorb heat during the day and release it slowly at night, helping to maintain stable indoor temperatures and reduce energy consumption. This makes it particularly effective for both summer and winter climates, reducing the need for heating and cooling systems (Green Building Advisor, 2024).

Wood fiber insulation is also known for its breathability, which helps regulate indoor humidity levels. This characteristic prevents moisture build-up, reducing the risk of mold and enhancing indoor air quality. Additionally, wood fiber insulation provides soundproofing benefits due to its dense structure, making it ideal for creating quieter indoor environments (STEICO, 2024).

From a sustainability perspective, wood fiber insulation is a standout choice. It is made from renewable resources and often from waste products, which helps reduce environmental impact. The production process typically involves minimal use of chemicals, and the finished product can be recycled or composted at the end of its life cycle. This aligns well with Oregon’s commitment to sustainable building practices (Build With Rise, 2024).

One of the leading manufacturers of wood fiber insulation is STEICO. Their products are known for their high quality and environmental benefits. STEICO’s insulation materials are certified by the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC), ensuring they come from responsibly managed forests. STEICO’s wood fiber insulation also offers excellent thermal and acoustic performance, contributing to energy-efficient and comfortable living spaces (STEICO, 2024).



STRAW BALE



Straw bale construction is gaining traction in Oregon due to its numerous environmental and practical benefits. This building method utilizes straw bales from cereal crops such as wheat, barley, and rice, turning agricultural by-products into valuable construction materials. This practice not only reduces waste but also promotes eco-friendly building practices by using renewable resources (Building Renewable, 2024; ScienceDirect, 2024).

One of the primary advantages of straw bale construction is its exceptional thermal insulation properties. Straw bales have a high R-value, typically around R-30 to R-35 for a two-foot thick wall, which is significantly higher than traditional insulation materials. This high thermal resistance helps maintain stable indoor temperatures, keeping homes warm in the winter and cool in the summer, thereby reducing energy consumption for heating and cooling (Green Building Advisor, 2024; Building Renewable, 2024).

Straw bale walls also offer excellent soundproofing qualities. The density and fibrous nature of straw bales dampen sound transmission, creating quieter indoor environments. This makes straw bale construction particularly beneficial in urban areas or near busy roads where noise reduction is crucial (ScienceDirect, 2024).

The fire resistance of straw bale construction is another notable benefit. When straw bales are densely packed and coated with plaster or another protective finish, they become highly resistant to fire. The tightly packed bales contain little oxygen, which is essential for combustion, and the plaster coating provides an additional protective barrier. This makes straw bale buildings safe and compliant with fire safety standards (Vanessa Salvia, 2024; Energy Studies in Buildings Laboratory, University of Oregon, 2024).

Straw bale construction is also highly versatile, allowing for creative and organic architectural designs. The flexibility of this material enables builders to create unique shapes and styles, from traditional to modern, incorporating curves and other non-linear forms with ease. This versatility, combined with its aesthetic appeal, makes straw bale construction an attractive option for architects and homeowners seeking distinctive and sustainable building solutions (Building Renewable, 2024; Green Building Advisor, 2024).

In terms of environmental impact, straw bale construction is a stand-out choice. It uses a renewable and biodegradable resource, significantly reducing the carbon footprint compared to conventional building materials. Additionally, the energy required to produce and transport straw bales is much lower than that for synthetic insulation materials, further enhancing its sustainability profile (ScienceDirect, 2024; Building Renewable, 2024).



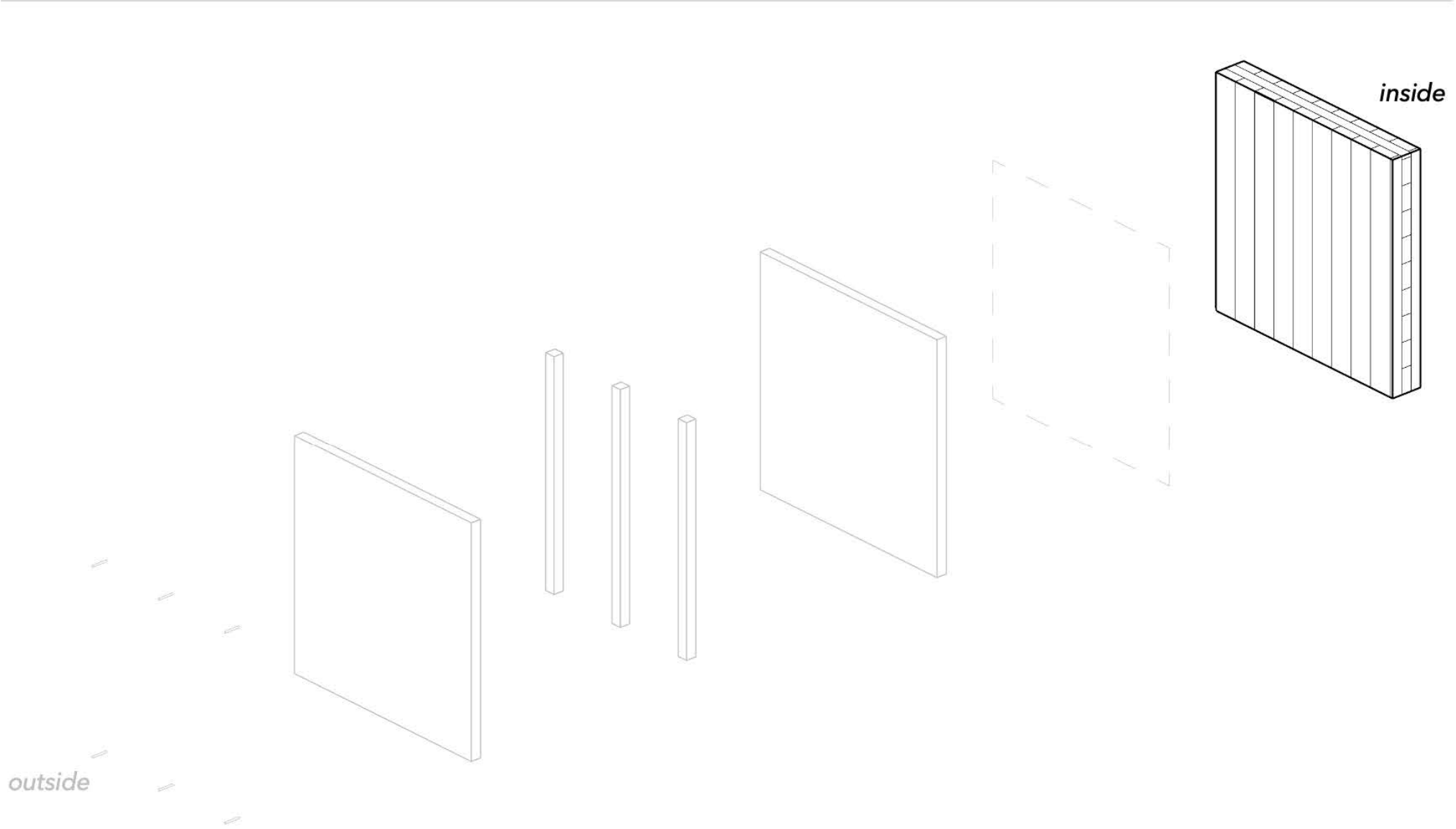
FURTHER EXPLORATIONS

CONNECTIONS

MATERIAL:
HARDWOOD DOWELS



CLT SPLINING



INGREDIENTS

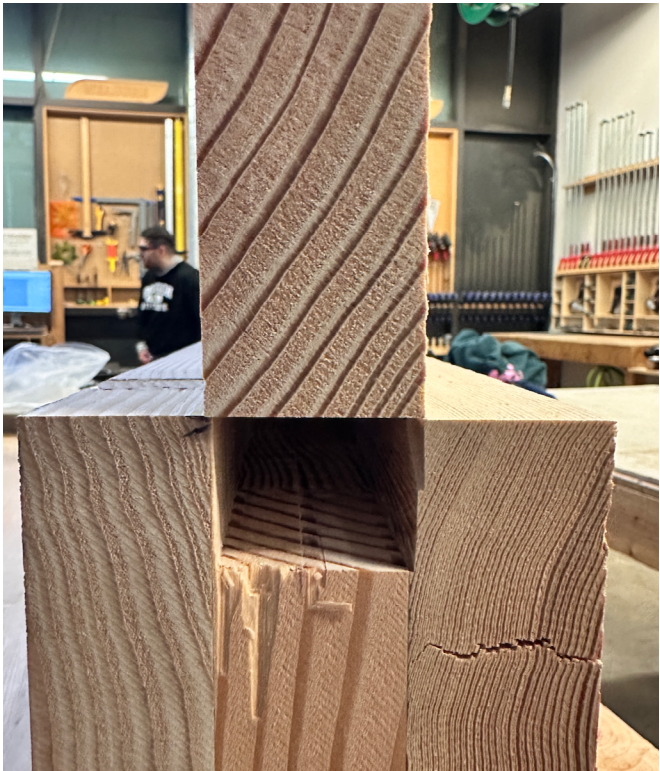
- CLT PANEL
- 2 X 6 WOOD BOARD CUT TO LENGTH
- GLUE
- WOOD SCREWS

EQUIPMENT

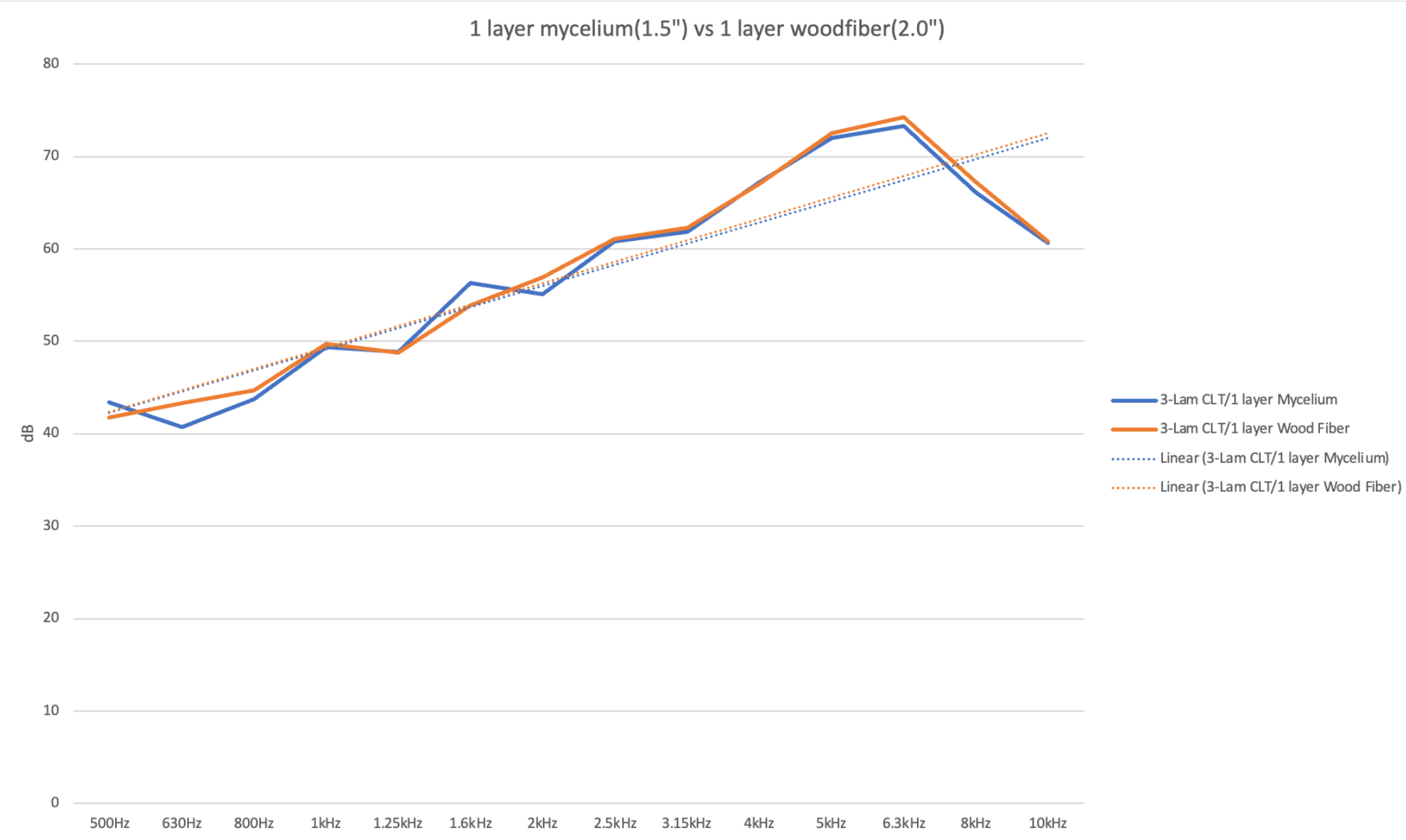
- TABLE SAW
- DADO BLADES
- STRONG ARMS
- ANOTHER PERSON
- IMPACT DRIVER
- CIRCULAR SAW
- PLANAR

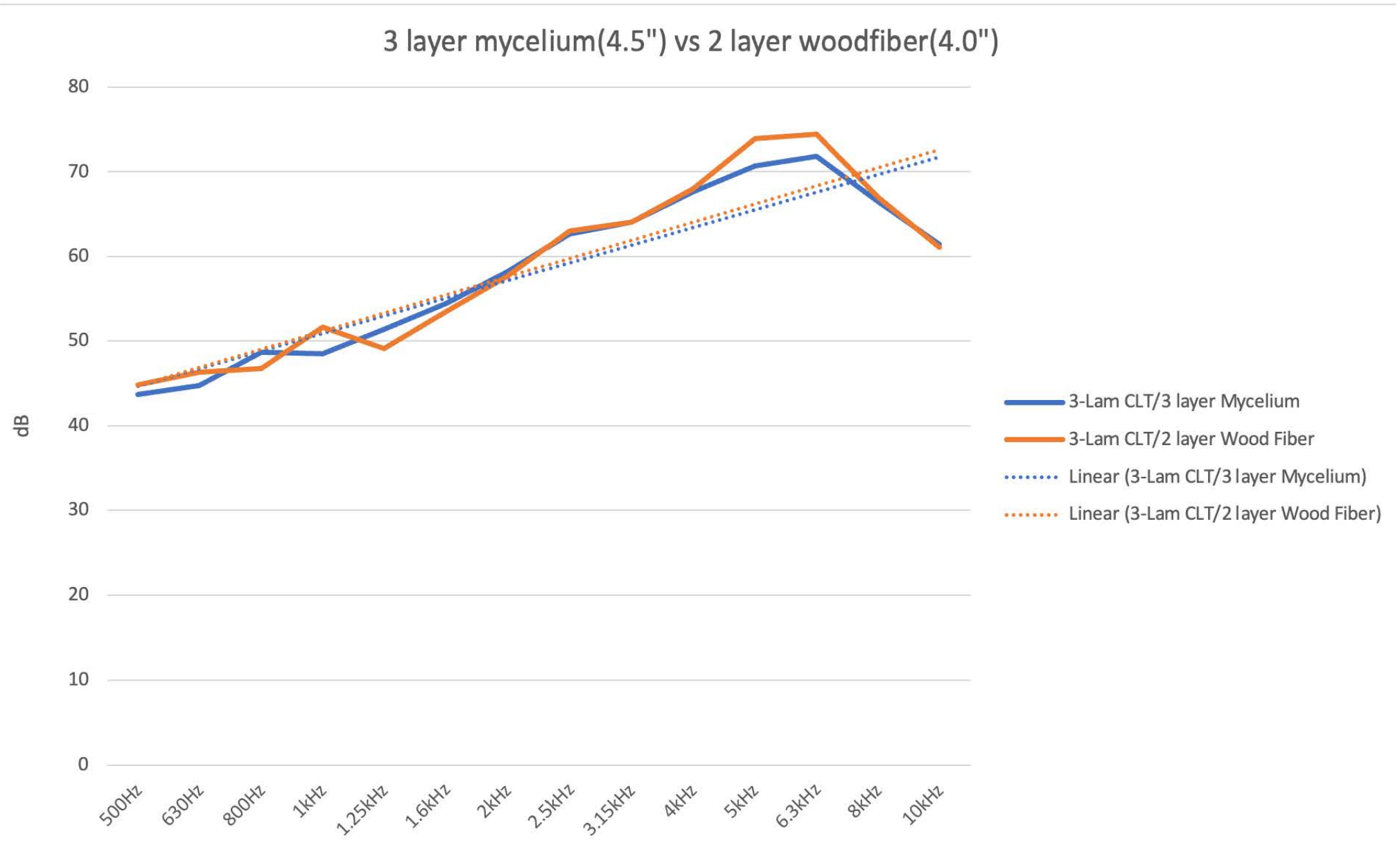
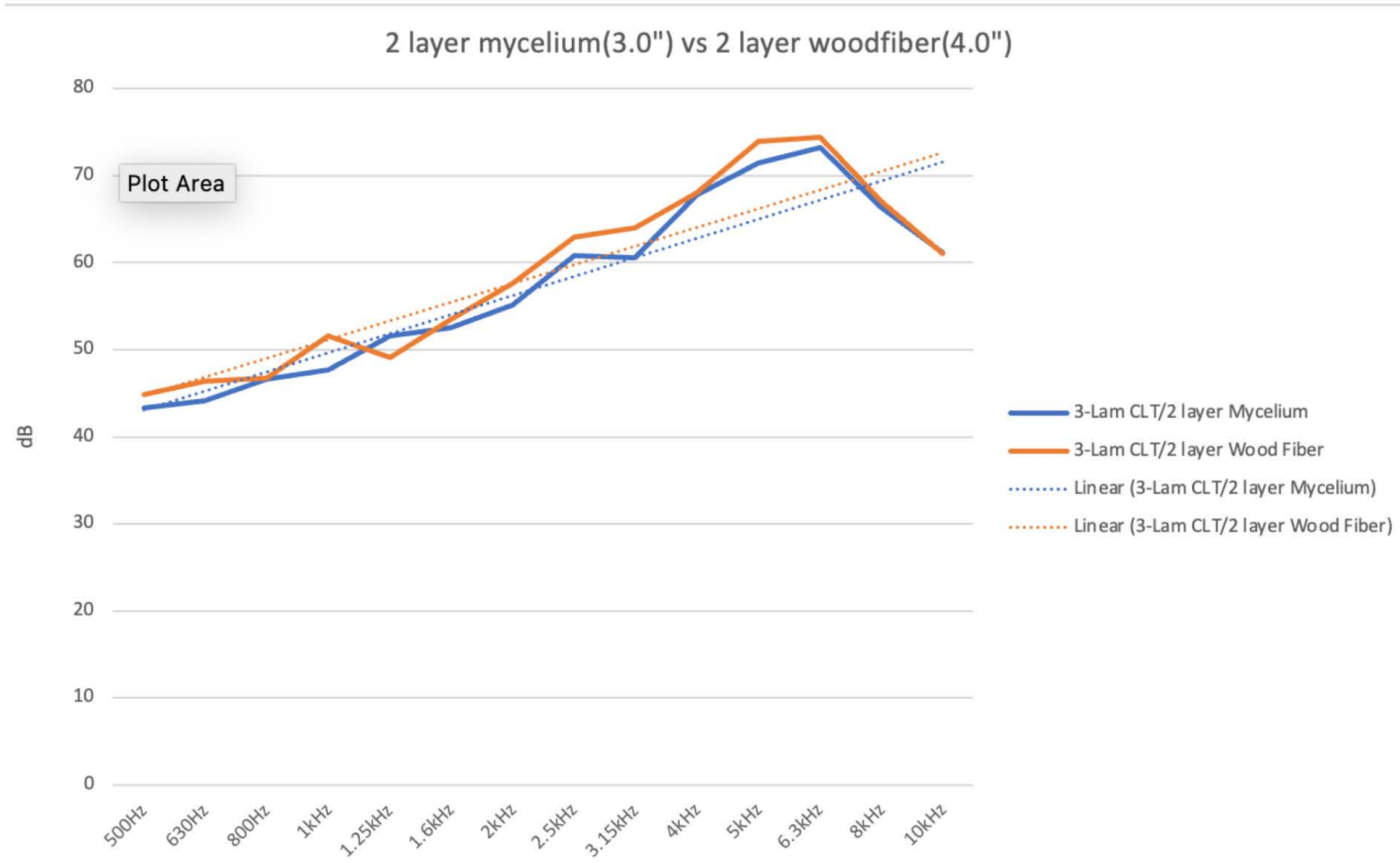
PROCESS

1. USING THE CIRCULAR SAW CUT YOUR 2 X 6 TO LENGTH
2. SET UP TABLE SAW WITH WIDE DADO BLADES
3. RUN YOUR CLT THROUGH ON THE LONG EDGE WITH ONE PERSON PUSHING AND AN-OTHER GUIDING
4. FLIP THE PANEL 180 DEGREES AND RUNG IT THROUGH AGAIN TO FIND CENTER
5. DEEPEN THE BLADE TO DESIRED LENGTH AFTER MAKING FIRST SHALLOW PASS
6. DO THIS WITH THE BOTH THE PIECES YOU ARE JOINING
7. TEST THE FIT OF THE 2X6
8. IF IT IS TOO THICK THEN RUNG THROUGH THE PLANAR
9. GLUE THE ROUTED IN MOUTHS AND PLACE THE 2X6 SPLINE INSIDE
10. SCREW THE PANEL IN AT EVERY 4 INCHES AND OFFSET THE SCREW PLACEMENT ON THE OTHER SIDE BY 2 INCHES TO CREATE A STRONG HOLD.

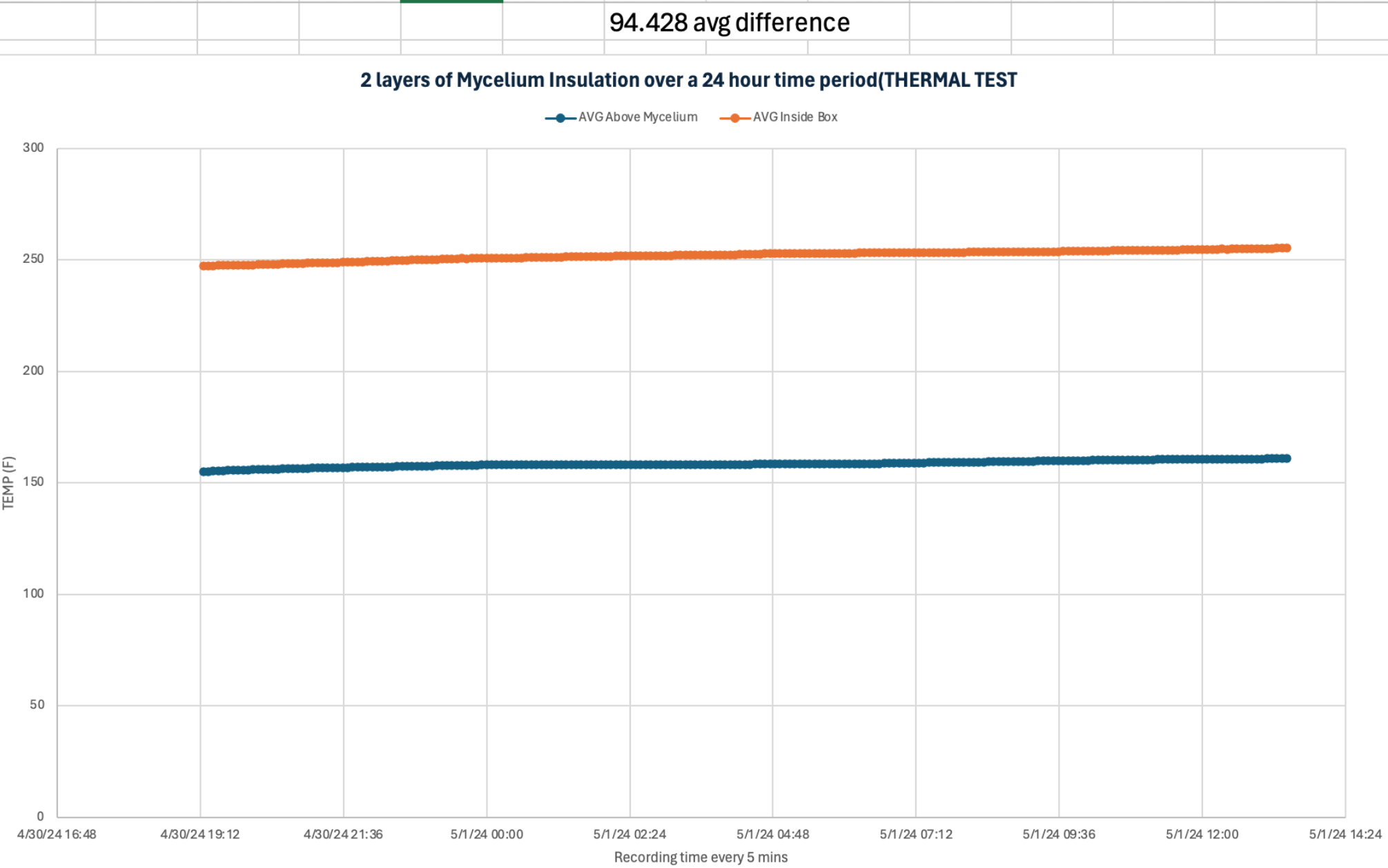


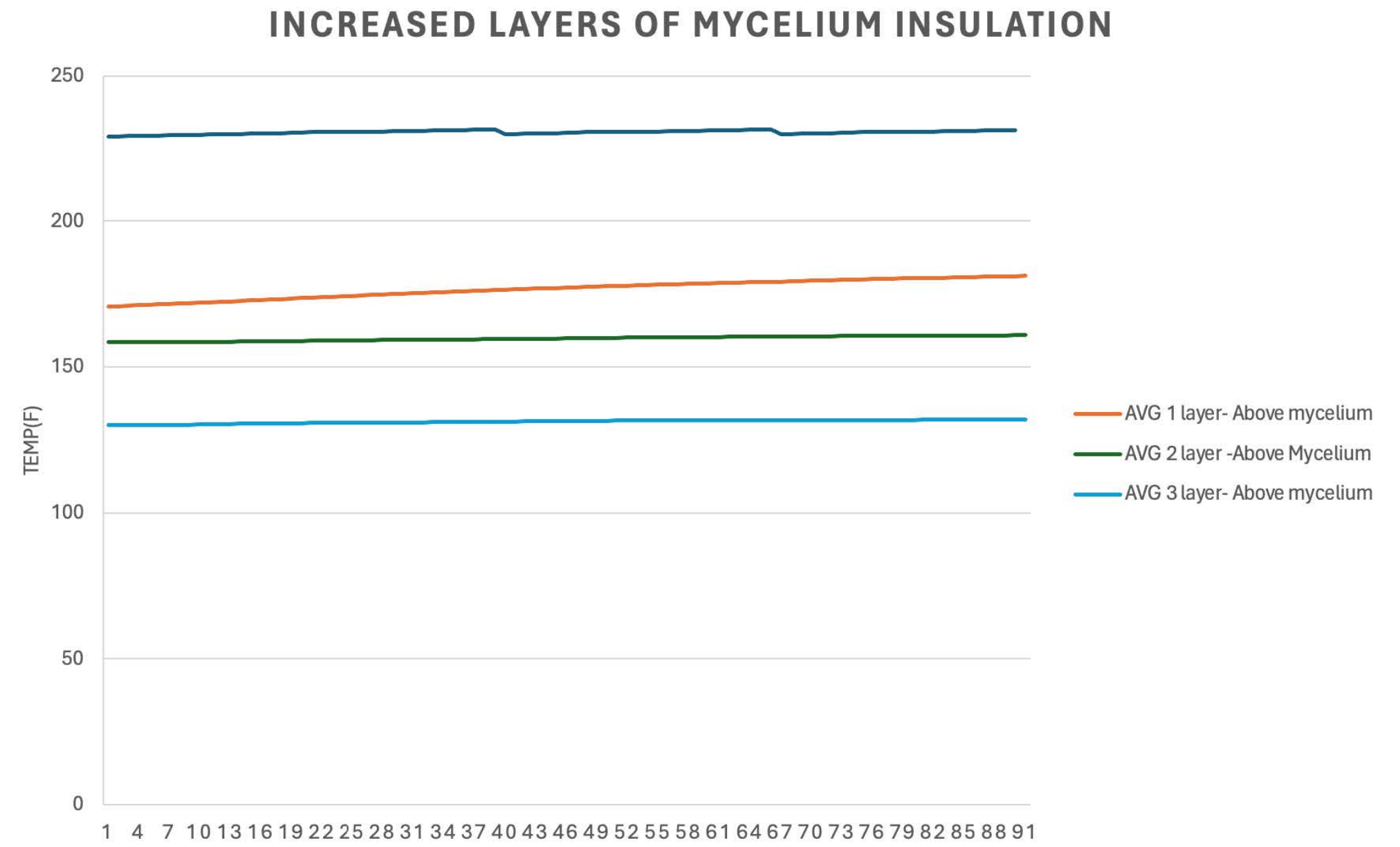
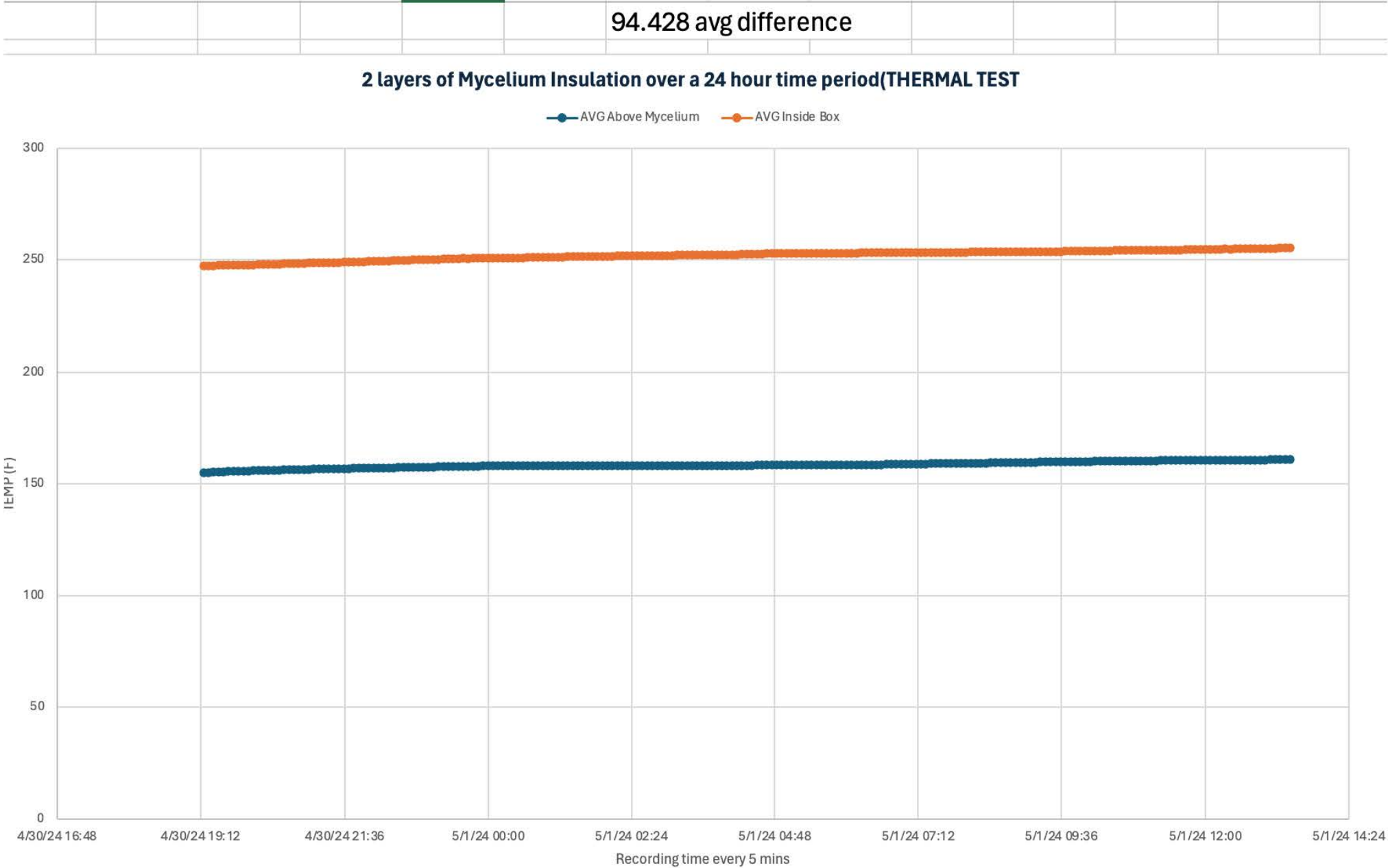
ACOUSTIC RESULTS
APPENDIX

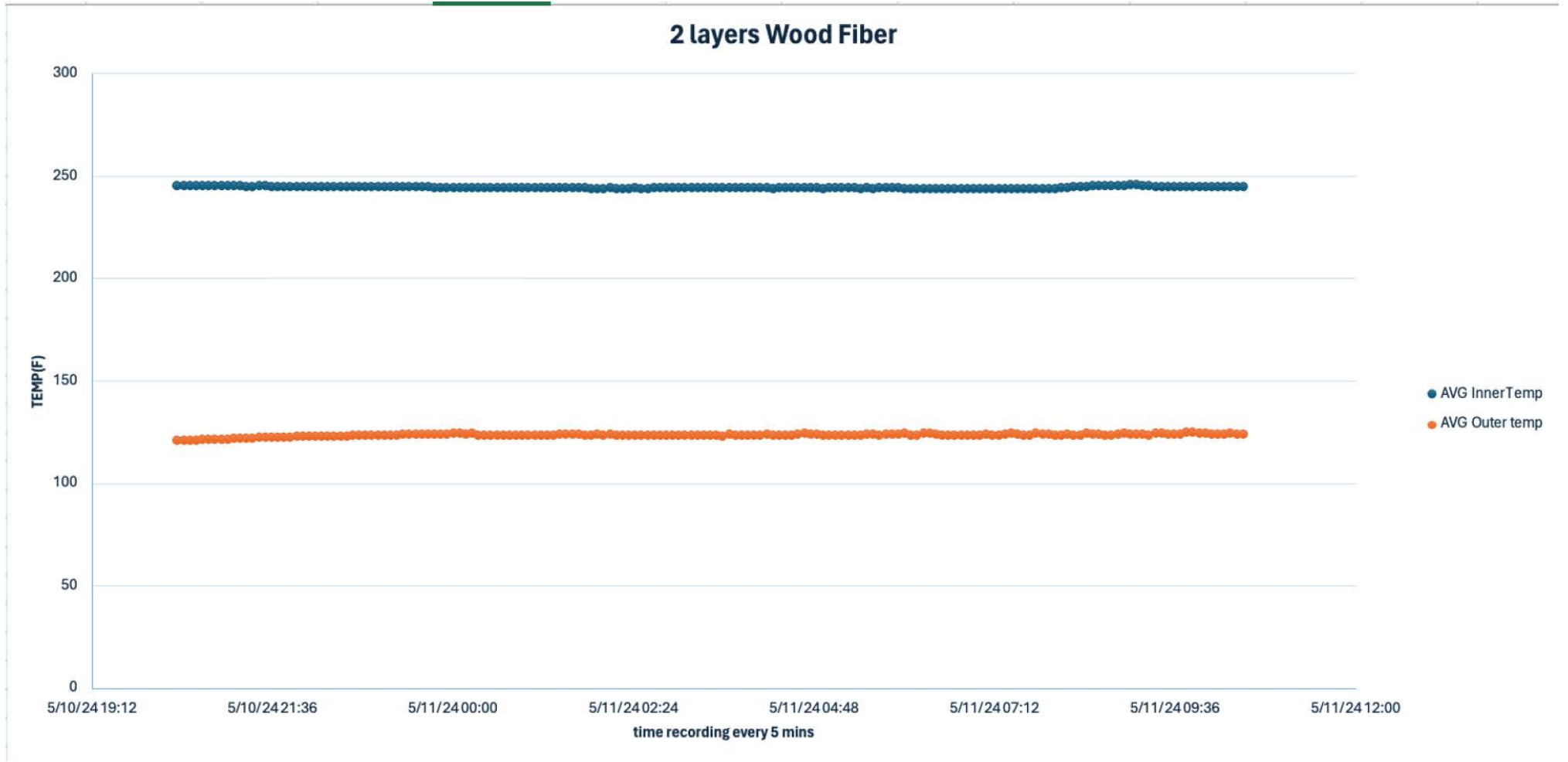
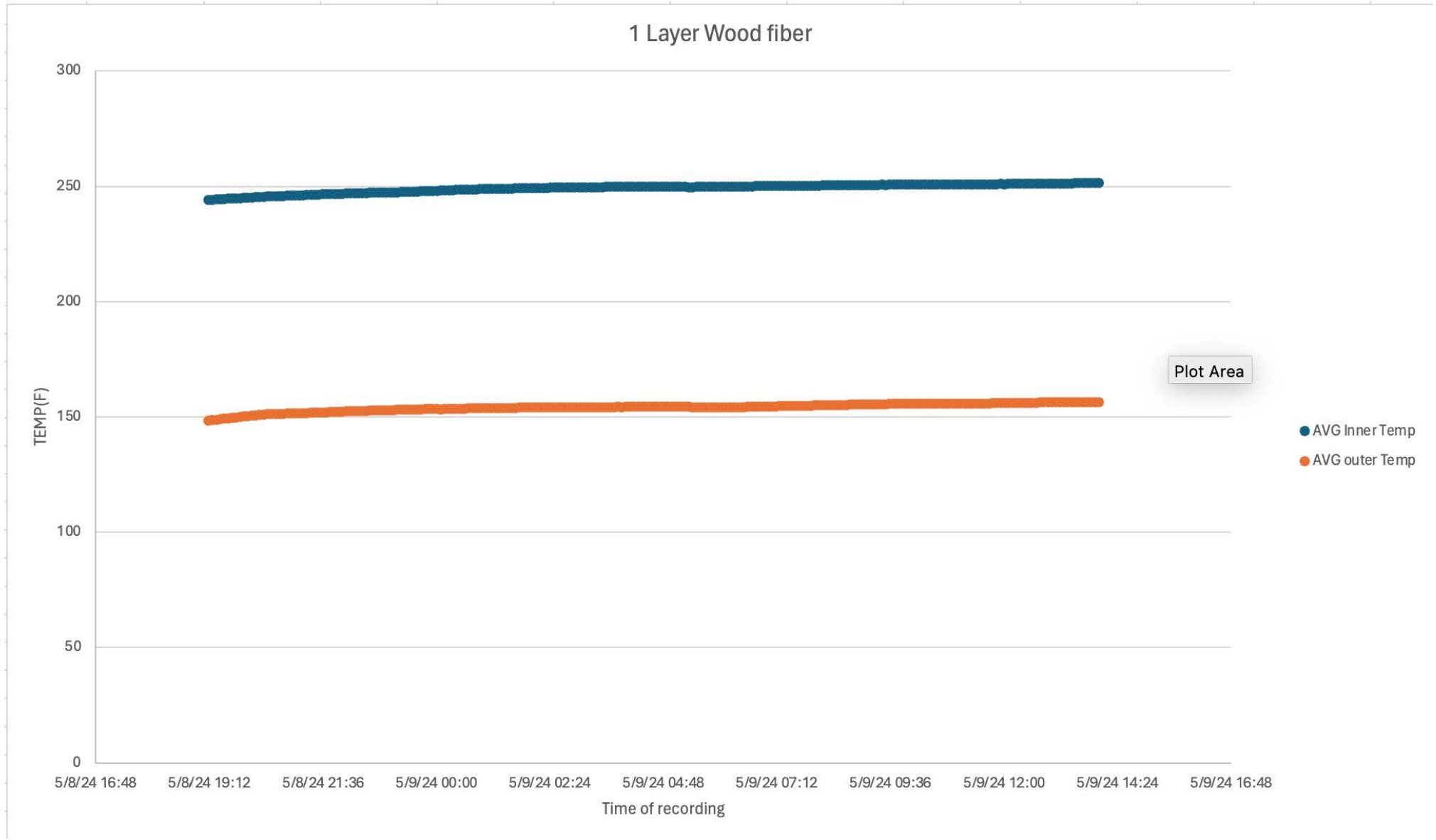


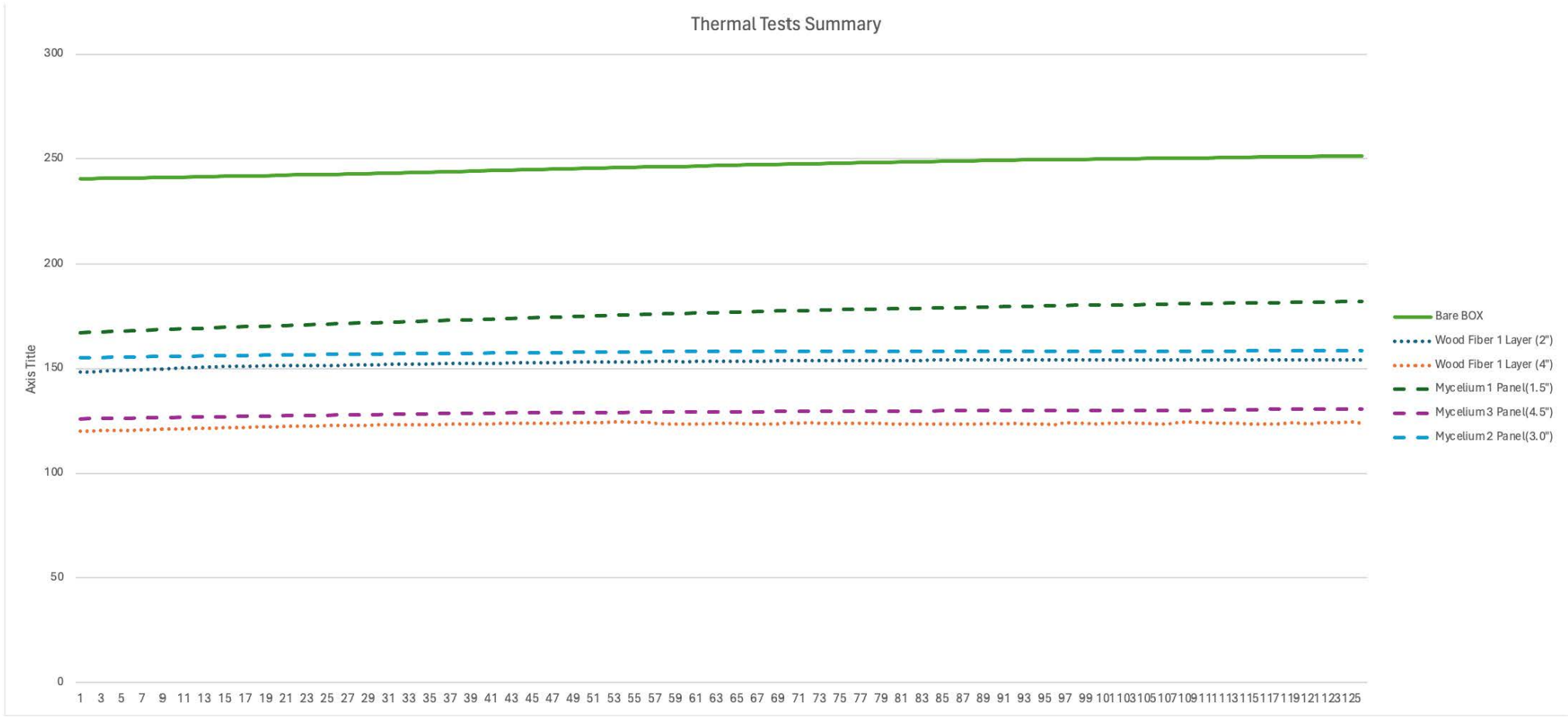


THERMAL RESULTS
APPENDIX









ANNOTATED BIBLIOGRAPHY

Source 1: E. Latif et al. “An Experimental Investigation into the Comparative Hygrothermal Performance of Wall Panels Incorporating Wood Fiber, Mineral Wool and Hemp-Lime.” *Energy and Buildings*, Elsevier, 31 Jan. 2018, www.sciencedirect.com/science/article/pii/S0378778817331687.

Summary: The study looked at three wall panels: the Biond Panel (a blend of wood fiber and hemp-lime), Mineral Wool, and Wood Fiber, all of which had the same computed U-values. It was discovered that the measured U-values were consistent in both steady state and dynamic hygrothermal situations. Notably, under intermittent heating settings, the Biond Panel showed the best heat storage and release capacities, while the Mineral Wool Panel showed the lowest. Strong moisture management capabilities within the framework of the Biond Panel were also demonstrated. These results imply that the greater thermal and hygric inertia of the Biond Panel may be able to lessen interstitial condensation and prevent housing overheating.

Source 2: Ikbal Cetiner , et al. “Wood Waste as an Alternative Thermal Insulation for Buildings.” *Energy and Buildings*, Elsevier, 11 Mar. 2018, www.sciencedirect.com/science/article/pii/S0378778817326749.

Summary: The use of wood waste as a thermal insulation material in timber frame wall construction is examined in this research. The thermal and hydric performance of wood waste that is obtained from primary production sources and left untreated is evaluated. According to the study, wood waste has thermal conductivity values that are equivalent to other natural insulation materials on the market but slightly greater than those of popular inorganic insulation materials when binders are not added. This inexpensive, environmentally friendly material has the potential to improve indoor environmental quality, facilitate the management of wood waste, and provide sustainable building insulation. Future hygrothermal modeling can be informed by the study’s hygric performance data.

Source 3: R. Pennacchio a, et al. “Fitness: Sheep-Wool and Hemp Sustainable Insulation Panels.” *Energy Procedia*, Elsevier, 28 Mar. 2017, www.sciencedirect.com/science/article/pii/S1876610217300528.

Summary: The research project “FITNESS” focuses on the development of an innovative semi-rigid thermal and acoustic insulation panel made from a combination of recycled sheep’s wool and hemp fibers. These panels offer low environmental impact and are designed for use in eco-building applications. also has excellent insulation properties and is resistant to mold and fungi. The hemp fibers, combined with sheep’s wool, create a high-density, eco-friendly insulation material.

Source 4: Briefing Paper - Western Juniper Commercialization Project, juniper.oregonstate.edu/sites/default/files/brfgpaper.pdf<http://juniper.oregonstate.edu/sites/default/files/brfgpaper.pdf>. Accessed 1 Nov. 2023.

Summary: The Western Juniper Commercialization Project seeks to create an industry using western juniper for sustainable resource management. This is necessary because the expansion of juniper woodlands has led to ecological concerns, and landowners are already removing juniper, which is costly. The project was initiated to utilize juniper as a new fiber source, especially after a significant loss of manufacturing jobs in the region.

Source 5: Brewer2, Matthew, et al. “Growing and Testing Mycelium Bricks as Building Insulation Materials.” *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 1 Feb. 2018, <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0213954>

Summary: This study investigates mycelium-based composites as an eco-friendly alternative to traditional materials. Various fibers and processing methods are examined, and the results demonstrate the potential of mycelium composites for thermal insulation, with their performance depending on fiber processing rather than composition. These composites show promise as sustainable alternatives to fossil-based materials.

Source 6: Elsacker, Elise, et al. “Mechanical, Physical and Chemical Characterizations of Mycelium-Based Composites with Different Types of Lignocellulosic Substrates.” *PLOS ONE*, Public Library of Science, journals.plos.org/plosone/article?id=10.1371/journal.pone.0213954. Accessed 2 Nov. 2023.

Summary: This paper examines mycelium-based materials as an eco-friendly alternative in the construction industry. These materials are created by infusing agricultural residue fibers with fungal mycelium, resulting in lightweight and biodegradable composites. The study delves into the production process and assesses the mechanical, physical, and chemical properties of mycelium-based composites made with various lignocellulosic fibers and the *Trametes versicolor* fungus.

Source 7: Jiwon Yoo a, Seong Jin Chang b, Sungwoong Yang a, Seunghwan Wi a, Young Uk Kim a, Sumin Kim a. “Performance of the Hygrothermal Behavior of the CLT Wall Using Different Types of Insulation; XPS, PF Board and Glass Wool.” *Case Studies in Thermal Engineering*, Elsevier, 12 Jan. 2021, www.sciencedirect.com/science/article/pii/S2214157X21000095.

Summary: The study analyzed building insulation using simulation and experiments. It found that vapor barriers inside walls reduced mold, and polyester insulation was better than wool. Glass wool insulation in Cross-Laminated Timber walls was vulnerable to heat and humidity, while PF insulation performed well. The research applied these findings to a CLT building and determined the optimal insulation thickness for different climates.

Source 8: Alina Galimshina a, Maliki Moustapha b, Alexander Hollberg c, Pierryves Padey d, Sébastien Lasvaux d, Bruno Sudret b, Guillaume Habert a. “Bio-Based Materials as a Robust Solution for Building Renovation: A Case Study.” *Applied Energy*, Elsevier, 13 Apr. 2022, www.sciencedirect.com/science/article/pii/S0306261922004883.

Summary: This study focuses on the urgent need for building renovation to achieve carbon neutrality by 2050. It explores the use of bio-based materials as an alternative to conventional materials in building retrofit, considering their potential for reducing energy consumption and temporarily storing carbon. The research combines life cycle assessment (LCA) and life cycle cost analysis (LCCA) while addressing uncertainties in long-lasting building systems. Robust optimization techniques are employed to identify the most cost-effective and climate-friendly renovation solution, indicating that combining bio-based envelope insulation with replacing fossil heating systems can achieve the highest reduction potential.

Source 9: Parker, R. and L. Burrill. “Invasive Weeds in Forest Land: Gorse - Oregon State University.” *OSU Catalog Extension*, catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1593.pdf. Accessed 15 Nov. 2023.

Source 10: Abed, Joseph, et al. “A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures.” *MDPI*, Multidisciplinary Digital Publishing Institute, 5 May 2022, www.mdpi.com/2071-1050/14/9/5570.

Summary: This study explores Mass Timber Construction (MTC) as an eco-friendly alternative to traditional building materials like concrete and steel. It addresses the urgent need to reduce CO2 emissions in the construction industry and examines MTC’s potential as a renewable and low-carbon building material. The research aims to provide a comprehensive overview of MTC, its performance criteria, and its advantages compared to concrete and steel, ultimately advocating for its wider adoption in construction as a sustainable and high-performance choice.

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THANK YOU

I WISH YOU A HAPPY JOURNEY IN DISCOVERING BIO MATERIALS IN
YOUR OWN REGION AND HOPEFULLY WE TAKE THESE SMALL STEPS
TOGETHER TO MAKE A BETTER FUTURE FOR EVERYONE