Nature-Based Performance Lab Insight Brief

Reimagine Buildings Collective–SUMMER 2025

Nature-Based Performance Lab

Lab Members: *Greg Bishop, Tom Hootman, Chris Magwood, Buck Moorhead, Rainger Pinney, and Nidhi Shah*

Can Bio-Based Materials Be Successfully Incorporated in High-Performance Design?

Challenge

We asked: Can bio-based materials such as straw, hemp, cellulose, and wood fiber not only meet but enhance the goals of high-performance building design?

High-performance design aims to deliver buildings that are: **healthy, comfortable, safe, durable, and regenerative.** Achieving this requires airtight and water-tight construction, vapor-open assemblies for drying, adequate insulation for comfort, and ventilation for clean air. It also means using fire-safe materials that minimize flame spread and toxic smoke.

Top Takeaways

1. **Bio-Based Materials Align with Performance Goals.**
   Materials like straw, hemp, cellulose, and wood fiber are vapor-open, hygroscopic, heat-buffering, and can improve airtightness when dense-packed. They also store carbon, come from renewable sources, and char predictably under fire exposure without producing large amounts of toxic smoke. Bio-based material performance is a synergistic match with low-energy and Passive House buildings, and many of these materials are inherently regenerative.

2. **They Outperform and Have Proven Precedent.**
   Compared to many petroleum-based options, bio-based insulation offers better moisture management, resilience against mold and rot, and improved thermal comfort in climates with wide temperature swings, especially when paired with modern detailing and membranes. Cellulose insulation is a strong precedent: dense-packed, vapor-open, hygroscopic, and already trusted and widely used in North America. Highlighting cellulose alongside new demonstration projects shows that bio-based materials are not risky novelties, but logical extensions of a proven approach. *Note: Properties like hygroscopic buffering are only beneficial when assemblies are designed to dry properly. If drying is restricted, such as by non-permeable finishes, these same materials can retain excess moisture. Considering the whole assembly and real-world occupant behavior is essential to manage this risk.*

3. **Research, Testing, and Code Adoption Are Crucial.**
   Designers and builders may hesitate until insurers and code officials are convinced. The challenge is less about material performance and more about validation and advocacy. Important testing is already underway, but its impact would grow with stronger coordination, funding, and visibility. Building on existing efforts through shared research, demonstration projects, and advocacy for code updates will be key.

4. **Policy and Market Drivers Can Accelerate Adoption.**
   The UK and Europe are ahead of the USA in adopting bio-based materials, partly due to whole-life carbon assessments and targets. Establishing similar frameworks in the USA could drive stronger market demand. At the same time, the rapid growth of mass timber construction in the USA offers a platform to leverage this interest and growth to promote a wider range of biomass-based material options.

What's Next?

To make bio-based materials a standard part of high-performance design in North America, the next steps are clear:

Expand Research & Testing – Strengthen the evidence base for durability, fire

safety, and long-term performance. Aggregate information from completed projects—both recent builds and older examples—to give confidence in long-term outcomes. Work with the Bio-based Materials Collective to encourage researchers, testing groups, designers, and builders to collect and share data in accessible formats, ensuring that anyone exploring these materials can easily find reliable, trustworthy information.

Advance Code Adoption – Translate these results into recognized pathways for approval in regional and national codes. Demonstrating proven compliance helps remove regulatory barriers and provides design teams with clear, repeatable routes to approval.

Showcase Success – Map recently completed and in-progress demonstration projects using cellulose, straw, wood fiber, and other bio-based materials. Standardize data monitoring and testing protocols for these projects, and create a shared portal (potentially stewarded by the Bio-based Materials Collective) to collect and publish this information, including options for anonymous contribution. By making this knowledge accessible and searchable, we can normalize bio-based solutions, highlight successful precedents, and accelerate adoption across the industry.

The question we leave with: *How can we collectively accelerate the research, code adoption, and storytelling needed to make bio-based materials a trusted default in North American high-performance construction?*

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