Sustainable Envelopes with Structural Engineered Bamboo

(SEB) Engineered Bamboo Products deliver structural, and renewable, bio-based solutions for high-performance building enclosure systems.

By C.C. Sullivan

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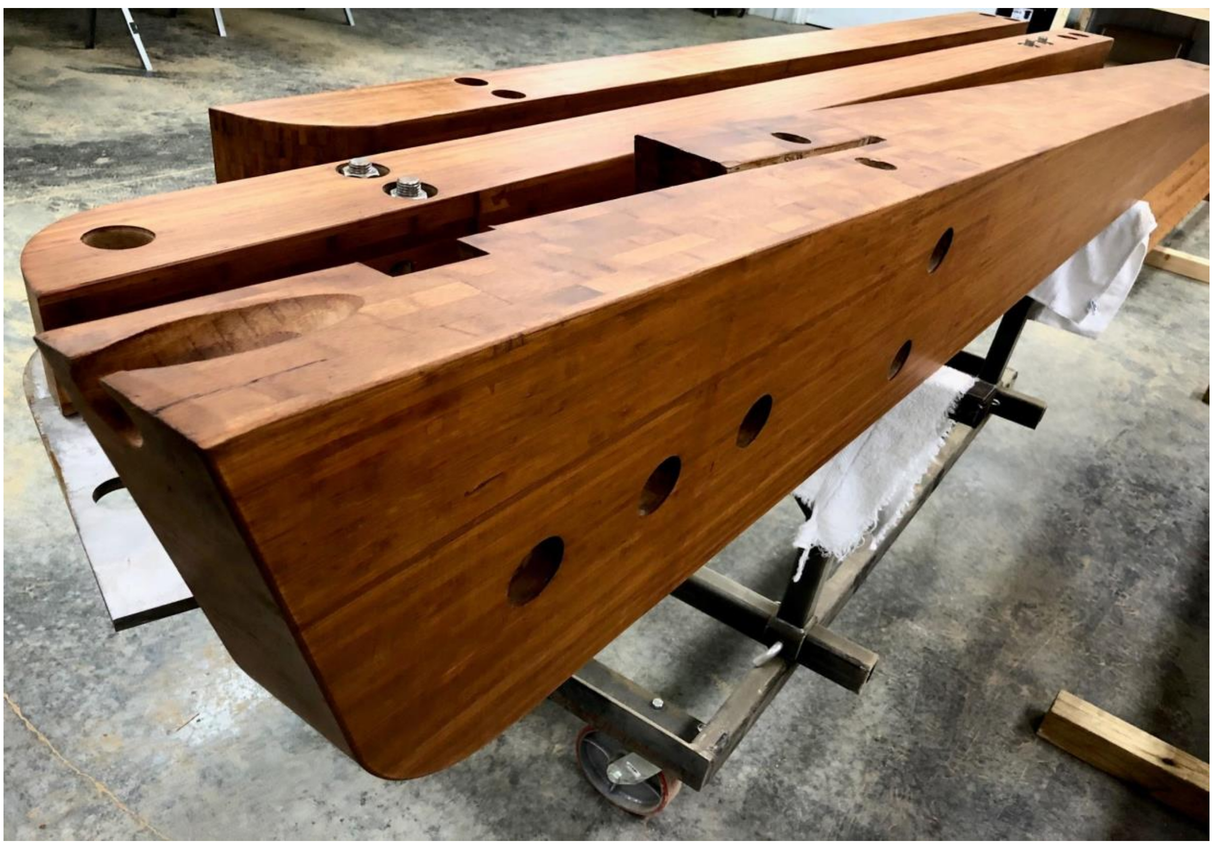


Image Provided by ReNuTeq, Inc.

Learning Objectives:

1. Describe engineered bamboo and SEB as high-performance, bio-based, and rapidly renewable green building materials and related building methods.
2. Discuss typical applications of structural bamboo products to building envelopes and structures that increase the use of rapidly renewable materials.
3. Identify general criteria for designing building envelope systems with engineered bamboo and SEB, including codes and standards, for greater use of rapidly renewable bamboo.
4. Explain how recent developments in structural bamboo products and SEB construction products apply to various envelope options and performance needs for high-performance green building.

Bio-based material technology companies are developing a range of new products that improve both building sustainability and performance. In some cases, these architectural materials and systems also increase efficiencies in design and construction. One prominent example has emerged over the past decade with the introduction of dimensional, prefabricated components of performance-grade engineered bamboo. The benefits of the bamboo structural products are especially evident in the design of building envelopes and enclosures, from curtain walls to windows and doors.

Employed for building structures and other architectural and original equipment manufacturer (OEM) applications, the bamboo-based panels, dimensional components, and hybrid systems offer warm, natural aesthetics. Yet engineered bamboo products (EBPs) can replace timber and engineered wood in architectural works where higher performance is desired, both in terms of sustainability and dimensional stability. Architects are beginning to find that structural engineered bamboo can serve well in contexts where metal, steel, or extruded aluminum assemblies are the norm. Hybrid solutions are also more common in recent years, a design approach pairing bamboo with steel, concrete, and other structural materials.

Curtain Wall Image Provided by ReNuTeq, Inc.

Modular, prefabricated components of structural engineered bamboo are used for building enclosures to provide high performance, sustainability, and dimensional stability.

Part of the benefit is for increasing the use of rapidly renewable materials—bamboo-based materials—in green building construction to include structural components that are typically made with wood, plastic, metal, or concrete. With increased use of engineered bamboo, building projects may qualify for several credits toward LEED v.4 certification, including:

LEED Points

- EAc2: Optimize Energy Performance
- MRc3: Sourcing of Raw Materials
- MRc4: Material Ingredients
- EQc2: Low-Emitting Materials
- Inc1: Innovation

Behind the scenes, manufacturers are discovering ways to boost the performance of engineered bamboo to achieve greater sustainability as well as improved durability, uniformity, and strength. This means that architects and end users can rely on structural engineered bamboo for longer spans, larger loads, and more extreme conditions. Facilitating these advancements are manufacturing enhancements to make stronger and more durable glulam beams and common dimensional components, as well as hybrid structural solutions and complete systems. In addition, more options are available to project teams needing assistance in using EBPs. For architects, today's manufacturers of EBPs offer EBP consulting, shop drawings, detailed structural system analysis, engineering, custom three-part specifications, fabrication, and installation advice as needed for their projects.

For these reasons, EBPs, as well as laminated veneer bamboo (SEB) materials are increasingly used for building exteriors and as exposed, load-bearing members. For sustainable buildings and LEED-certified projects, EBPs are used for facades, cladding, curtain walls, structural glazing, as well as a range of window and door solutions.

The use of engineered bamboo for structural systems have been well established. What is changing is the variety and creativity of uses in recent building designs. An example of this is the Williamson County Regional Airport terminal project in Marion, Illinois, designed by the architecture and engineering firm RS&H. As seen in the above picture, it has a novel domed roof structure with hybrid steel-and-bamboo cross bracing for a central atrium. The structural bamboo beams are visible in the ceiling within the terminal and provide a unique design feature to this project.

Other examples include an entry for the U.S. Department of Energy's Solar Decathlon by the University of Illinois at Urbana-Champaign, using engineered laminated bamboo for structural elements and reclaimed barn wood cladding. Certified by the U.S. Passive House Institute, the innovative project called Gable Home uses 90 percent less energy than typical construction.

According to the university's assistant professor Mark Taylor, "Using laminated veneered bamboo helped our team become the first competitors in the DOE's Solar Decathlon competition to achieve Passive House Certification, both at the competition site and back in Illinois, where the house returned after competing in the 2009 event."

Engineered Bamboo: Context and Background

Considered an alternative material technology, engineered bamboo takes advantage of “a rapidly renewable material that has many applications in construction,” according to Dr. Bhavna Sharma, a structural bamboo expert and lecturer at the University of Bath’s Department of Architecture & Civil Engineering. “Engineered bamboo products result from processing the raw bamboo culm into a laminated composite, similar to glue-laminated timber products.” Dr. Sharma continues by stating, "This bio-based resource also resembles wood in its mechanical properties, yet it has a faster growth rate and harvest cycle."[1] In addition, bamboo is found in many places where softwoods and hardwoods are limited.

Image Provided by ReNuTeq, Inc.

Essentially a giant grass, the bamboo plant comprises a hollow, tapering culm (stalk) of longitudinally oriented fibers divided by nodes. From the interior to the exterior, the bamboo fibers increase in density. These fibers are essential to creating structural-grade engineered bamboo. One manufacturing method produces strand-woven or parallel-strand bamboo, made from crushed fiber bundles soaked in resin and treated under pressure to create solid, dense slabs. A second method, known as laminated bamboo, also maintains the longitudinal fibers as the parallel-strand process does, but it also takes advantage of the natural culm matrix. The bamboo stalks are cut and planed, and then processed as desired prior to the lamination and compression in board form. This process typically utilizes less adhesive and tends to provide higher strength-to-weight values.

Today, attention has shifted to applications by architects, engineers, and OEMs for interiors, exteriors, and structures. The strength and efficiency of EBPs and SEBs—along with the positive carbon footprint of rapidly renewable bamboo—make it a suitable choice for high-performance buildings. Yet, adherents within the industry and the construction community have focused on how to design with structural bamboo products. The findings have included innovative architecture on the one hand, and on the other hand a raft of innovations in modularity, system integration capabilities, and installation techniques. The products are also engineered for a high degree of uniformity and consistency, ensuring tolerances within those required for building enclosures and structures.

Engineered glulam beam made of Structural Engineered Bamboo (SEB) incorporating stainless steel plating and hardware - Image Provided by ReNuTeq, Inc.

Engineered bamboo products are engineered for uniformity, consistency, and typical construction tolerances so they can be used just as readily as steel, aluminum, or plastic components. As a result, structural bamboo can now be incorporated into an architectural project's envelope just as readily as its steel, aluminum, or plastic counterparts. In some cases, as is outlined in this course, there are advantages to using bio-based materials over traditional metals and other structural systems.

Enclosure Systems and Structural Bamboo

For such varied enclosure systems as fenestration, curtain walls, and rainscreens made with engineered bamboo products offer a few inherent advantages. While the engineered bamboo functions in ways similar to engineered wood and can be worked with standard carpentry tools, it can be more sustainably sourced, and it tends to have very minimal shrinkage and better dimensional stability. Engineered bamboo products have natural antimicrobial properties so they resist moisture build-up and through unique processing methods can help prevent decay or rot from the core of the materials. Bamboo's high silica content acts as a natural insect deterrent. Engineered bamboo tends to have a slightly higher density than common hardwoods, which increases its capacity to be used in applications where traditional hardwoods would perform poorly.

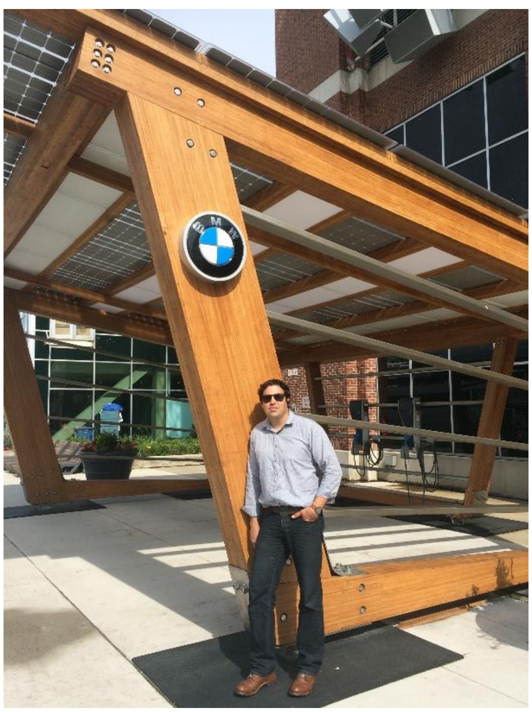
These products also offer aesthetic attributes where other materials used in these applications need to be covered up by additional building materials to achieve a certain look wanted by the architect and designer. Bamboo provides a unique aesthetic that can be admired by the end user. The unique look of engineered laminated bamboo is becoming more accepted and appreciated by today's architects and designers looking for a natural product that does not need to be covered up by additional building materials which help reduce overall cost of time and labor in projects.

In summary, SEBs can be described as similar to wood glulams but with more functional consistency and better dimensional stability, all things being equal. SEBs also can provide reduction in overall cost for projects by reducing the need to utilize additional building materials to cover up the exposed engineered bamboo materials.

Studies conducted by the University of Bath's Dr. Bhavna, using common wood standards to allow comparison with engineered timber products, have shown that engineered bamboo boards or "scrimber" and laminated bamboo have properties that compare with or surpass those of timber.[1] Other testing results by industry groups, such as PFS, Inc., show that high-performance engineered laminated bamboo members, tested parallel to the grain, have compressive strengths exceeding 8,300 psi per ASTM 3501-86A and tensile strengths of between 8,700-9,000 psi. The dimensional stability, tested per ASTM D 1037, shows the products to be more stable in varied environmental conditions. Summarizing the results, engineered SEBs:

- have mechanical properties comparable to hardwoods.
- exhibit compressive strengths greater than softwoods.
- have tensile strengths greater than other wood species.
- are more dimensional stable in moisture and temperature changes when compared to timber-based product (dependent on wood species).

In order to allow for system modularity, which translates into efficient architectural integration, SEBs are available as standard shapes, including beams, glue-laminated (glulam) members, exposed trusses and members, as well as hybrid assemblies in combination with cold-formed steel joists. Similar to timber glulams, engineered bamboo products are available through catalogs of modular structural components, which can be pre-assembled and serve as elements of pre-engineered construction systems. To include wood joinery techniques and structural connections, these members are fitted with steel plates and clips as well as pre-drilled to allow for efficient jobsite connection.



"Our work initiated by Bruce Craig (Formerly of Weyerhaeuser) and me in 2007 of adding SEB/LVB into ASTM allows architects to specify Structural Engineered Bamboo for the first-time making SEB the first major new structural product added to the standard in over 35 years". Stated ASTM's DO7.02.03 Task Group Chairman, and Founder/CEO of ReNüTeq, Inc. Luke D. Schuette. Luke is the innovator behind SEB (Structural Engineered Bamboo) who is credited for creating the first Structural Beams for testing in 2003 in his family barn.

Structural bamboo products (SEBs) custom fabricated and used in conjunction with Stainless Steel Plating. Structure Designed By Luke D. Schuette – Imaged Provided by Luke Schuette, CEO and Founder of ReNuTeq, Inc.

In other cases, some building companies are adopting modular construction approaches using engineered bamboo. In these project delivery methods, the buildings (or elements of the building) are constructed off-site under controlled fabrication conditions to meet all design needs and prevailing codes and standards. Produced in modules, the resulting structures can be assembled and put in place typically in less time than conventional, site-built facilities, according to the Modular Building Institute.[2]

Applications of engineered bamboo for modular or conventionally constructed high-performance enclosures and exterior structures include curtain walls, sunshade systems, canopies, and trellis components. In addition, architects can specify modular and prefabricated solar structures or design any exposed post-and-beam assemblies using pre-engineered bamboo members. Laminated veneer bamboo (SEB) can also be used as rainscreen cladding on SEB substructures. Engineered bamboo is also used for roof beams, curved beams, rafters, and columns, as well as intermediate purlins or substructures. Products for structural and enclosure applications most prevalent on the market today include:

- **Structural glazing:** This comes in the form of curtain wall members, storefront system components, point supported structural glass, and installation integrated as a thermally high-performance hybrid aluminum/SEB.
- **Structural bamboo products (SEBs):** These include fabricated common dimensional components, glulam beams, and hybrid structural applications. Manufacturers and glu-lam fabricators can offer consulting, shop drawings, structural system analysis, engineering, and installation support for architects working with engineered bamboo.
- **Enclosure and exterior products:** These include window and door components that are integrated into glazing solutions to provide efficiency and continuity within turnkey glazing systems. Rainscreen systems include exterior wall/ceiling cladding and siding solutions, soffit, fascia, exterior products, including awnings, site furnishings, and playground equipment, bollards, trellises, and more.
- **High-performance, sustainable buildings:** In these structural and nonstructural applications, SEBs may contribute to as many as five LEED credits, depending on the application and project details.

Applications For Structures and Enclosures

For these and other typical bamboo construction applications, SEBs and EBPs are available in two grades: exterior grade and structural grade. Solid exterior grade EBP may be specified in 07, such as 07412 (wall panels) of the Construction Specifications Institute (CSI) Manual of Practice and Master Format. For structural grade SEBs, the specification is typically within division 06, the section that also accommodates parallel-strand lumber, glue-laminated beams, engineered wood products and structural timber, and rough carpentry, among others.

Several ASTM International standards may be referenced for the structural grades of engineered bamboo. Most relevant is the ASTM D5456: Standard Specification for Evaluation of Structural Composite Lumber. This standard, developed with the ASTM Technical Subcommittee D07.02.03 on Structural Composite Lumber, may apply to cellulosic materials used for structures and veneers. For that reason, engineered bamboo falls under the auspices of the Technical Committee (TC) D07, which interfaces with various TCs, including E06 (Performance of Buildings), E05 (Fire Standards), D14 (Adhesives), and C16 (Thermal Insulation). In addition to standard D5456, architects may also reference other standards in project construction documents, which among others may include:

- D1037: Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
- D1761: Standard Test Methods for Mechanical Fasteners in Wood
- D5055: Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists

Standards, such as ASTM sD5456: Standard Specification for Evaluation of Structural Composite Lumber, apply to cellulosic materials used for structures, including engineered bamboo, such as for these structural beams used at an Illinois airport. Engineered glulam beam made of Structural Engineered Bamboo (SEB) incorporating stainless steel plating and hardware - Image Provided by ReNuTeq, Inc.

Though the products had been in use previously, in 2010, a watershed moment arrived for the structural application of engineered bamboo. For SEBs and the structural grades of manufactured bamboo products, that year ASTM announced an imminent revision to D5456 that "would add bamboo as a fiber material that can be used in the manufacture of products covered in the standard," said the group. According to ASTM staff member Kevin Shanahan, director of standards development, "D5456 was originally approved in 1993 and specifies the procedures necessary for a group of engineered wood composite products to be evaluated for all structural design properties that would allow them to be used as substitutes for solid sawn lumber and glue-laminated timbers in residential and commercial building construction."

"Our work initiated by Bruce Craig (Formerly of Weyerhaeuser) and myself in 2007 of adding SEB/LVB into ASTM allows architects to specify Structural Engineered Bamboo for the first-time making SEB the first major new structural product added to the standard in over 35 years". Stated ASTM's DO7.02.03 Task Group Chairman, and Founder/CEO of ReNüTeq, Inc. Luke D. Schuette.

Today, instead of referencing only traditional wood species used for solid sawn lumber, D5456 has been revised to include bamboo as another lignocellulosic fiber material—in other words, biomass—that can be used in the manufacture of these products.

The historic addition of bamboo to the standard came in the 2012 edition of the *Annual Book of ASTM Standards*, listing SEB as a certified product for structural applications under ASTM 11a 5456, with the heading "Evaluation of Structural Composite Lumber Products." At the time, the broadening of the standard was hailed by some sustainability advocates and others interested in increased use of rapidly renewable resources, such as bamboo. In fact, it was the first addition in more than three decades of a bio-based structural material to the ASTM annual compendium.

While the ASTM standards added to the appeal of EBPs, the International Code Council (ICC) had already intoned on use of engineered bamboo for structural applications. In a 2009 meeting in Birmingham, Alabama, a vote passed to make SEB a newly ICC accredited product for the following year. Engineered bamboo had been used for years as a finish product, including widespread adoption for wood-look flooring.

Prior to that, the product category had its own criteria, AC162: Structural Bamboo, released in March 2000 with test methods, allowable design stress criteria, and other design considerations. This was the first codes document to recommend ASTM D5456 as a quality-control standard. It also provides reference to the International Network for Bamboo and Rattan (INBAR) Standard for Determination of Physical and Mechanical Properties of Bamboo.

It is valuable to note that the novel engineered structural component products made with bamboo culm do not perform identically to those made from traditional wood species. The bamboo-based products tend to have better dimensional stability than engineered wood, while their greater density also increases thermal transfer slightly over their wood-based cousins.

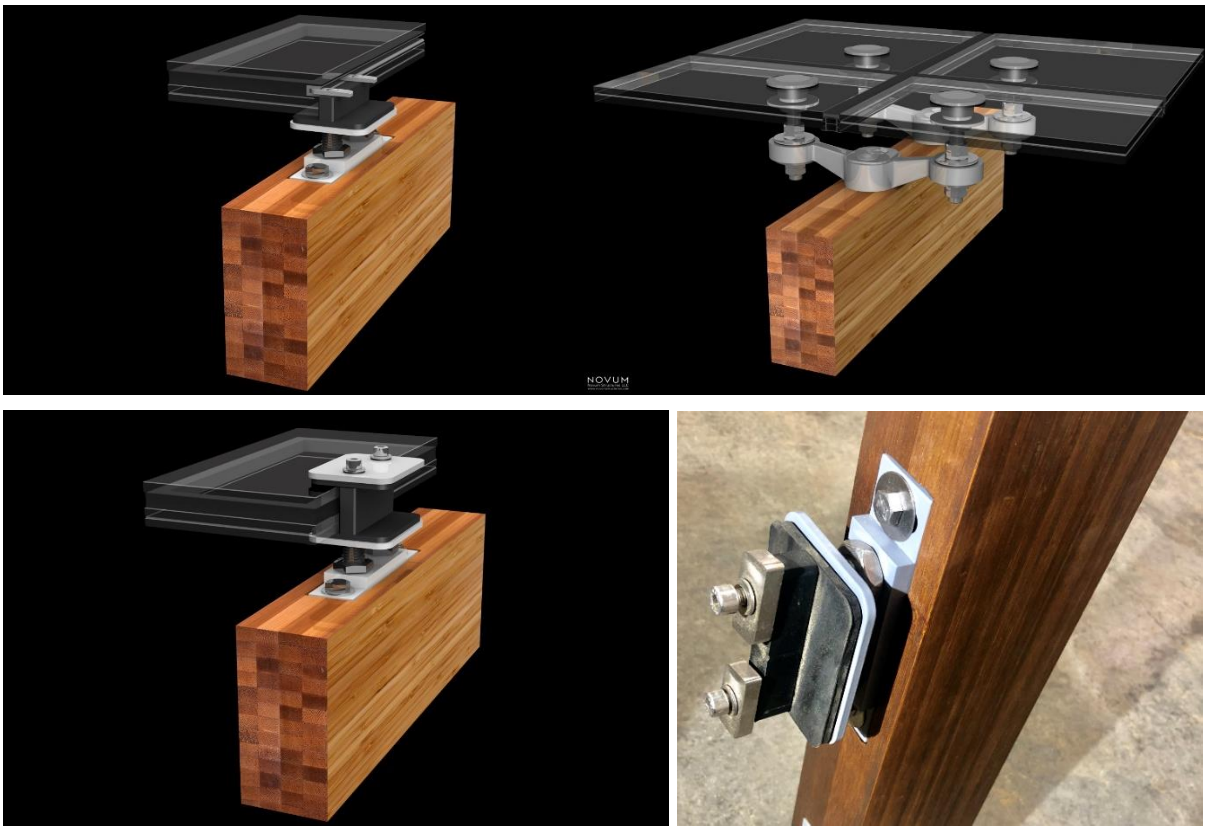
Sustainable Facades and Structural Glass Systems

With bamboo-based structural elements readily employed as glulams, LVL, and structural composite lumber, architects and project teams have increasingly designed facade systems, such as structural glass, storefront, and curtain wall systems, using SEBs. Among the most promising approaches for storefronts and curtain walls is a thermally high-performance hybrid of extruded aluminum framing attached to SEB members for vertical members, mullions, muntins, and horizontal rails. Although non-load bearing as with all curtain walls, as a backup system, these hybrid members support the weight of the glass framing, effectively transferring that weight back to the structure. The engineered bamboo members are generally left exposed, which is ideal for the aesthetic characteristics of the materials. A variety of companies have begun utilizing SEB members into their product offerings to the glazing market.

In curtain wall systems, glazing can be secured to hybrid aluminum and EBP backup systems using a captured glazing, structural silicone, and point-support systems. Mullion caps of profiled aluminum or engineered bamboo provide a finished look. - Image Provided by ReNuTeq, Inc.

In these curtain wall systems, the glazing can be secured to the hybrid aluminum and SEB backup systems using a variety of typical approaches, including captured glazing, structural silicone, and point-support systems. Mullion caps of profiled aluminum or engineered bamboo provide a finished look, inside and out. In fact, the bamboo members replace a large portion of the aluminum typically associated with window walls, storefronts, and curtain wall systems—and they can replace the backup supports as well. The result is a wood-hued bamboo grid, with its pleasing texture and warmth.

Recent projects have included a split-mullion design by one architect, adding a unique and complex look to the SEB members in the curtain wall grid. Instead of a solid mullion, the vertical members appear as two side-by-side lengths of engineered bamboo separated by a 1-inch or 2-inch gap.



Structural Glass Systems as Hybrid – Steel and SEB (Structural Engineered Bamboo – Images Provided by NOVUM Structures, and ReNuTeq, Inc.

Door details by some millwork and window makers have also been tailored to complement the clean sightlines of recent curtain wall designs.

Expanding this design language with a more consistent materials palette, some architects have used matching sunscreens and shading devices of engineered bamboo to complement the storefronts and curtain walls. Others have added trellises, pergolas, and other matching EBP structures and finishes. In some cases, the curtain wall and storefront systems are matched with load-bearing columns of structural bamboo in front of or behind the facade. High-performance laminated bamboo is applied to beams, glulam members, exposed trusses, and hybrid steel/SEB assemblies.

In general, these structural elements compare favorably with lumber, plywood, and wood composite products. SEBs have comparable strength properties to other hardwoods but offer better dimensional stability as well as contemporary aesthetics and sustainable characteristics not found in traditional or exotic woods and other engineered products. With further developments in exterior treatments as well as adhesives and binders, SEBs are expanding in areas well beyond where traditional soft and hard woods can be utilized. In terms of pest resistance, testing has indicated that bamboo processed with borate pressure treating prior to lamination records 100 percent termite mortality. Durability against wood-destroying fungi is very high due to the inherent antimicrobial properties of bamboo, with some variation expected based on proprietary treatment and curing processes employed. Many of the EBPs and SEBs are indigestible to insects and microorganisms, helping improve their durability and resiliency.

Due to the aesthetic characteristics of the materials, engineered bamboo is best utilized in situations where it is left exposed. This is a key advantage in regard to cost associated with additional labor and materials now not needed to cover up the exposed materials as done with typical wood glulam beams or structural members. SEBs have already appeared in the window and door industry, where structural stability is a must. This allows window and door manufacturers the capability of producing dimensionally stable members that meet a broad range of project needs. With these offerings, EBP and SEB have found a following among architects working in both residential and commercial building types.

ENGINEERED BAMBOO SPECS FOR HIGH-PERFORMANCE FACADES

For new enclosure designs using engineered bamboo, good structural performance and thermal characteristics are just a start. The benefits of exterior-grade and structural-grade EBPs, including SEB, reach across all types of variables encountered in specifying and detailing facade systems. Architects designing with engineered bamboo should be aware of the following general specifications for the facades and EBP elements:

1. **Material integrity.** Specify materials manufactured to meet or exceed basic performance criteria, including water absorption of less than 1.0 percent based on EN 438-2 (7). Make sure that the material is nonporous, especially on all exposed surfaces and edges. For color stability, the ISO standard 105 A02-87 (a 3,000-hour xenon lamp test) should yield a 4 to 5 grey scale.

2. **Healthy materials.** Engineered bamboo provides a valuable specification for architects and their clients who desire materials that do not support microorganic growth. This can be specified under "microbial characteristics" for both structural and exterior grade products. In terms of cleanliness, properly finished engineered bamboo can be easily cleaned with typical cleaning solutions used on other typical wood or natural based products.

Windows and Doors, Engineered With Engineered Bamboo

Fenestration components made with SEB and other EBPs are now on the market designed for efficient integration into glazing systems and engineered bamboo structures. The components are specifically designed for insulated glazing units (IGUs), window, and door thermal performance as well as strength, rigidity, and water-resistant attributes. This makes them an effective choice for sustainable design challenges.

One of the benefits is that the engineered bamboo materials have tested to be more stable in climate and temperature changes than engineered woods. Engineered bamboo materials present better mechanical properties over typical natural wood materials, which means they are ideal for window and door products and assemblies. SEB functions similarly to hardwoods; however, SEB has a much better dimensional stability and as a building product can be more sustainably sourced. Some project teams and end users see SEB's antimicrobial properties as a benefit since the resulting windows and doors resist moisture buildup. Silica content within the material acts as a natural insect deterrent as well.

For high-performance facades, the windows are higher in density than hardwoods, which allows for more resilient and durable fenestration structures—which are often relative weak points in the enclosure. The density also means moderate thermal bridging as compared to softwoods, but this is offset by other performance advantages, says Schuette. For operable units, the material's stability also allows for more uniform and smooth operation throughout the building's use phase.

In comparing density, typical softwoods used in light residential windows weigh about 36 pounds per cubic foot. SEB is much denser with a density of about 44 pounds per cubic foot, making SEB a more dimensionally stable and efficient material over typical softwoods. Since window and door applications are more susceptible to the changes in temperature and moisture, it is key to integrate a material that can withstand extreme changes in both temperature and moisture.

SEB materials and components, whether standard dimensional or custom, can be used for commercial entries, operable windows, movable wall systems, lift and slide systems, garage doors/openings, and skylights, as well as storefront and curtain wall assemblies. The product can be milled with the same tools as hardwoods, making production easier for fabricators and manufacturers of fenestration products. In today's market, full system and installation services for products integrated as thermally high-performance hybrids of aluminum/SEB, a solution offered by a number of manufactures, installers, and glaziers internationally.

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One of the key trends in enclosure design has been the adoption of performance standards in the U.S. Green Building Council's LEED certifications and even more so with the super-efficient Passive House standards. These programs require architects and their teams to demonstrate a specific level of energy efficiency in order to be certified. According to the Passive House Institute US, the standards and passive design in general are defined based on five building science principles: continuous insulation throughout the entire envelope without thermal bridging, an airtight envelope, heat-recovery and moisture-recovery ventilation, controlled solar gain, and high-performance windows and doors. The windows are frequently triple-paned and may include a fill, such as argon. High-performance window and doors of this type using SEB have been used successfully in Certified Passive House structures.

Among the recent advances in window design is a SEB European-designed window with hardware that revolves the window 180 degrees for cleaning and maintenance without encroaching into the building interior spaces. Another is a storefront system offered with various window hardware types as well as folding, sliding, entry, and lift-and-slide doors. The manufacturers have adopted engineered bamboo because of its mechanical properties and natural aesthetics. Some manufacturers have also introduced operable and motorized fenestration systems in the last three to five years. The operable inserts can be placed in any part of the enclosure layout and include inswing and outswing venting lights in both manually operated and fully automatic motorized systems.

High-Performance Bamboo: Case Studies

Some recent projects show how EBPs have been used in adding value to creative projects. In as well-publicized and carefully tested application, engineered bamboo took center stage at the 2009 Solar Decathlon applied to a residential project with traditional looks and materials as well as some cutting-edge energy technologies. Created by the architecture program at the University of Illinois at Urbana-Champaign, the solution includes 100-year-old barn wood and high-efficiency solar panels arranged with a gable roof profile. "Inside, the newest structural bamboo and optimized windows, insulation, and appliances mean it can be heated with a single hair dryer," according to the design team.

The structural bamboo material was chosen for its renewable characteristics and superior structural performance. Suggesting Midwestern agricultural vernacular, the simple form employs barn wood siding, a barn door-like sliding shade structure, and decking made of reclaimed wood from a grain elevator.

Called Gable Home, the project was designed for certification by the U.S. Passive House Institute in Urbana, Illinois, using 90 percent less energy than typical construction. "Structural Engineered Bamboo for structural elements is stronger than wood and more rapidly renewable," according to the team's DOE page. It also benefits from a "laminated bamboo structure that minimizes thermal bridges." Other key performance-driven selections include about 12 inches of wall, roof, and floor insulation, a high-efficiency, small-air-volume HVAC system, and a solar array generating about 9.1 kW of DC power.

Williamson County Regional Airport Terminal – Structural Engineered Bamboo Roof System

In a very different application, the durability and beauty of structural laminated bamboo are already on display at the new 23,000-square-foot replacement terminal for the Williamson County Regional Airport in Marion, Illinois. Utilizing a pre-engineered hybrid dome of structural steel and engineered bamboo cross beams, the architects of RS&H created a soaring display of exposed structure visible overhead in the terminal's central court.

Pictured: Luke Schuette (Innovator of SEB and Graduate of SIUC – School of Architecture), and SIUC – John K. Dobbins, Norm Lach, and Architecture Students. (Southern Illinois University – School of Architecture. Image provide by Luke Schuette (Innovator Of SEB (Structural Engineered Bamboo and Graduate of SIUC)

ARCHITECTURAL RECORD
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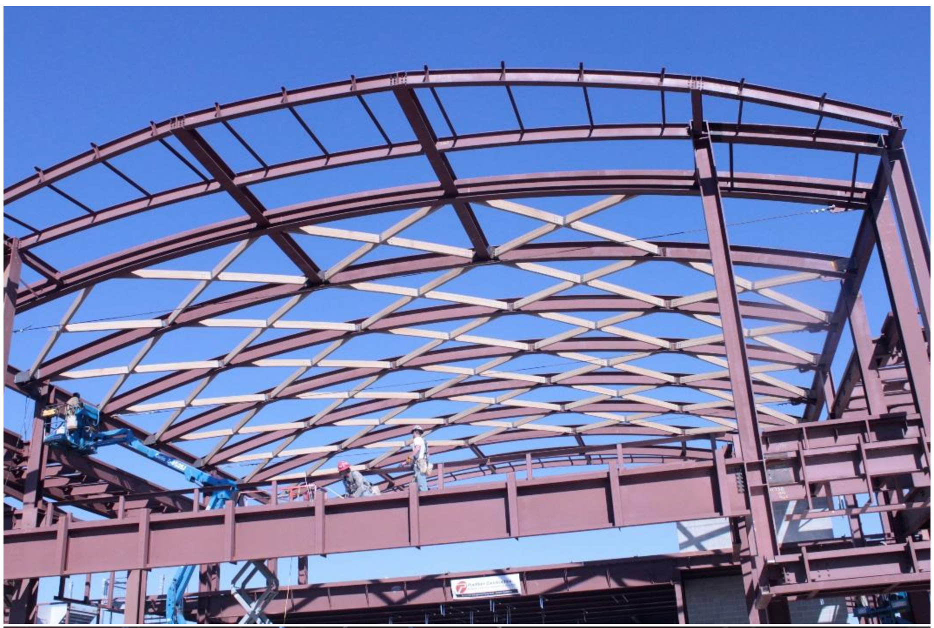
Structural Engineered Bamboo is on display at the new 23,000-square-foot replacement terminal for the Williamson County Regional Airport in Marion, Illinois, with its pre-engineered hybrid dome of structural steel and engineered bamboo cross beams, designed by the architecture and engineering firm RS&H.

[7] "I am pleased to see that the materials that were envisioned while in School at SIUC in 2002 are now implemented in such an innovative way and so close to my school." Stated Luke Schuette, Innovator of SEB (Structural Engineered Bamboo) and Founder of ReNuTeq, Inc.



Images provide by Luke Schuette (Innovator Of SEB and Graduate of SIUC) **Pictured:** Luke Schuette (Innovator of SEB and Graduate of SIUC), and SIUC – Professors of Architecture – Dir of Master's Program John K. Dobbins, Professor: Norm Lach, and Master's Architecture Students. (Southern Illinois University – School of Architecture, Dennis and Joan Schuette of Schuette Design Architects.

Due the inspiration of SEB (Structural Engineered Bamboo) by Luke Schuette while in Architectural School, Luke invited Faculty and Masters of architecture students from nearby Southern Illinois University, Carbondale visited the project site to witness the exposed gridwork and framing before the roof assembly was set by the contractor. Sixteen-foot curved EBP beams attaching to 64-foot arcs of curved steel. Created as a showcase of sustainability and innovation, the new terminal marks the first airport in the United States to have an entire roof structure made of structural engineered bamboo, according to the Williamson County Airport officials, when it opened in the fall of 2016.

Remarking on the project, the project supplier noted that inherently as a raw material, as a bio-based material, the dimensional bamboo is stronger than timbers on average. In tensile strength, it's more than two times stronger when you compare it to other timber products relative in size and density. In addition, the roof grid is visible to travelers below in the innovative, sustainable design by RS&H, an integrated architecture and engineering firm.

Other projects have expanded the use of engineered bamboo into civic facilities, institutional projects, commercial buildings, and more. The picture above provides another example of EBP's used in an exterior cladding application. The customer was interested in a natural based product that promotes beauty and warmth and can be used in exterior applications. With EBP's presenting performance, attractive aesthetic, and stability for interior and exterior applications, the customer received exactly what they were looking for in EBPs. Many architects still visualize the exposed stems and culms of unprocessed bamboo in structures both traditional and modern throughout South Asia, Southeast Asia, and East Asia. Yet, the significant benefits of SEB and other EBPs are changing their perceptions. Engineered bamboo and SEB is becoming shorthand for sustainable, high-performance structural materials that improve building operations, enclosure performance, and overall look of the final project.

Application Benefits

Some of the fastest-growing plants in the world are bamboo species, due to a unique rhizome-dependent system that lets them grow up to 10 centimeters per day.[3] In about three to five years, the plants reach maturity, as compared to 20 years or more for traditional timber. Bamboo also produces 30 percent more oxygen in comparison to similar-size timber forest area, according to a Santa Clara University study, and sequesters 35 percent more carbon.[4] Its unique root structure eliminates the need to replant. Bamboo is used widely as a building material, a food source, and as a versatile raw product. As noted in a Discover magazine report over two decades ago, bamboo's tensile strength rivals that for steel and it compressive strength is greater than that for concrete, brick, or wood.[5]

The use of rapidly renewable bamboo-based engineered materials in green building construction can now include structural components that are typically made with wood, plastic, metal, or concrete. With increased use of engineered bamboo, building projects may qualify for several credits toward LEED certification. The demand to use sustainable building material is becoming more relevant due to the increase in sustainable building practices and the reduction of using petroleum-based building products. SEB is a perfect solution to complement the requirements for sustainable building materials.

Another key feature to EBPs, SEBs, and SEB is their unique aesthetic look. These materials are now options to be used in fully exposed applications without the need to "cover it up" with other building materials like dry-wall or paint. The natural beauty of the material can be appreciated by the building owner. Since these products are also available in interior and exterior applications, continuity can easily be achieved and allow architects and designers the availability of using one material throughout an entire project. This benefit not only helps satisfy a visual requirement, but it also can help with the overall cost reduction of not using additional materials to achieve a look the customer is requiring or looking for.

The compressive strengths of SEB and other engineered bamboo elements exceed 8,800 psi (parallel to grain), which is greater than most softwoods. The tensile strengths of the products also provide a key advantage over traditional and engineered wood products. Since SEB provides higher dimensional stability over its wood counterparts, this is a key advantage point to architects to design projects with longer spans and know their design will hold true. Lastly, the silica content and arrangement within the material help the bamboo-based products resist termite and other pests.[6] Rigorous uniformity and consistency across the supply chains for EBPs adds to these good marks for basic material performance.

In summary, EBP, SEB, and SEB products are now being recognized in the architectural and building markets where manufacturers have dedicated their time and resources to enable access to this great building material to architects, engineers, interior designers, product specifiers, building owners, and other decision makers that focus on sustainable building practices. Through continued advancements in technology and engineering practices, EBP, SEB, and SEB (Structural Engineered Bamboo) products will become better and more available and allow for further expansion of utilizing these products through all facets of design. The architectural and building community can now rely on a sustainable building solution without the worries of deforesting our precious planet and continue the development of design solutions with a sustainable solution.

End Notes

[1]Sharma, B., Gatóo, A., Bock, M., and Ramage, M. "Engineered bamboo for structural applications." Construction and Building Materials, Volume 81, 15 Apr. 2015. Web. 26 March 2016. **http://www.sciencedirect.com/science/article/pii/S0950061815001117**.

[2]Modular Building Institute. "Why Build Modular?" Modular Building Institute. Web. 26 March 2016. **http://www.modular.org/htmlPage.aspx?name=why_modular**.

[3]Farrelly, David. The Book of Bamboo. Sierra Club Books. ISBN 0-87156-825-X, 1984. Web. 26 March 2016.

[4]"Bamboo." Santa Clara University, 2013. Web. 26 March 2016. **https://www.scu.edu/media/ethics-center/environmental-ethics/Bamboo.pdf**.

[5]Roach, Mary. "The Bamboo Solution: Tough as steel, sturdier than concrete, full-size in a year." Discover magazine. 1 June 1996. Retrieved 7 Dec. 2013. Web. 26 March 2016.

[6]St. Louis Testing Laboratories Inc. "Resistance of Two Bamboo Species Treated with Borates to Formosan Subterranean Termites (Coptotermes Formosanus) in a No-Choice Test." 2 Dec. 2004. Web. 26 March 2016.

Structural Data, Images of Structural Engineered Bamboo, and Project Details provided by ReNuTeq, Inc.

[7]Quotes by Luke D. Schuette, Founder and Owner of ReNuTeq, Inc. The initiation of "Structural Engineered Bamboo" started at the family farm when founder and owner, Luke D. Schuette prototyped the first structural beams for testing by laminating bamboo slats to create beams for structural applications in 2003 (his final year of architecture school at Southern Illinois University). This lead to his life's work as the internationally recognized researcher, creator, and innovator of the disrupting material technology: SEB (Structural Engineered Bamboo) for performance-based, architectural, & structural applications. Learn more Here

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