Designing with Bamboo for Superior Environmental & Human Health Impacts

Teragren LLC
12715 Miller Rd. NE
Suite 301
Bainbridge Island, WA 98110
Tel: 206-842-9477
Fax: 206-842-9456
Toll-Free: 800-929-6333
Email: Tom@teragren.com
Web: www.teragren.com

START

Designing with Bamboo for Superior Environmental & Human Health Impacts

Presented by: Teragren LLC
12715 Miller Rd. NE
Suite 301
Bainbridge Island, WA 98110

Description: Provides an overview of the history, uses, characteristics, and specification considerations of bamboo, including a discussion of the health advantages and green benefits of designing with bamboo products.

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REGISTERED CONTINUING EDUCATION PROGRAM

Purpose & Learning Objectives

Purpose: Provides an overview of the history, uses, characteristics, and specification considerations of bamboo, including a discussion of the health advantages and green benefits of designing with bamboo products.

Learning Objectives:

At the end of this program, participants will be able to:

- discuss the history, applications, and design styles of bamboo
- compare the properties of bamboo to other wood species in terms of durability, performance, carbon sequestration properties, and workability
- summarize the health benefits of specifying bamboo products, including improved indoor air quality,
- explain how bamboo is sustainably harvested and why bamboo is considered a rapidly renewable resource, and
- state how designing with bamboo products can qualify for green initiatives, such as USDA BioPreferred® Program and LEED®.

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An Introduction to Bamboo: History & Uses

Introduction

You have likely encountered bamboo products used in a variety of ways for interior finishes, furnishings, and accents. Bamboo building products first became available on a commercial scale in North America in the mid-1990s. The popularity of these products surged during the early 2000s due to their desirable aesthetic and unique, eco-friendly attributes.

Today, building products made from bamboo account for 5–10% of hardwood interior finishes, such as flooring, countertops, cabinets, and furniture, and the number is growing every year.

Early Cultivation of Bamboo

Bamboo has been a fundamental component of building design and construction in many Asian countries for thousands of years. Research into the applied use of bamboo for structural purposes has a recorded history in China at least 5,000–6,000 years old.

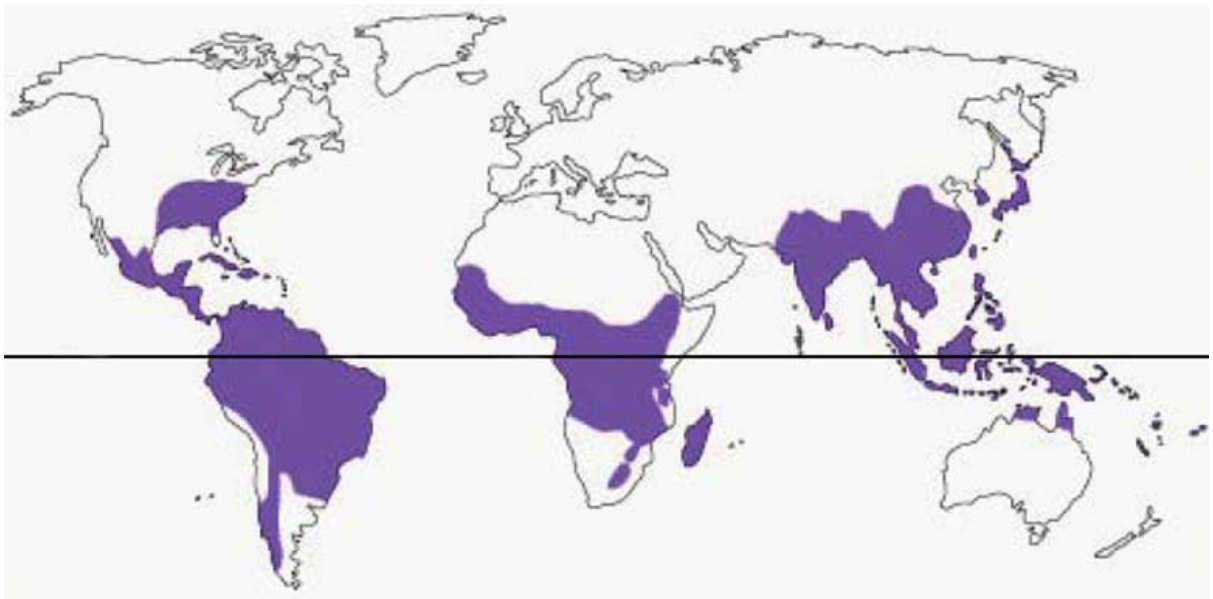
Intentional, managed cultivation of bamboo began in China 2,440 years ago, and has played a staple economic role in that country ever since.

Primary Uses of Bamboo

There are over 1,400 different species of bamboo that grow naturally on every continent, except for Europe and Antarctica. Most species are concentrated in tropical and sub-tropical zones.

How the bamboo is used depends on the type. Primary economic uses can include the following:

- Construction Scaffolding
- Edibles (bamboo shoots)
- Energy Production
- Fertilizer (biochar)
- Landscaping/Ornamental
- Interior Finishes



Global Bamboo Distribution

Benefits of Bamboo-Based Industries

In much of the developing world where bamboo grows naturally, the economic potential represented by these bamboo-based industries could create stable employment for up to one billion people worldwide. These industries would provide a resilient economic foundation for their communities without negative impacts to the surrounding ecosystem, creating viable, equitable, and bearable systems that are the cornerstones of socio-economic and environmental sustainability.

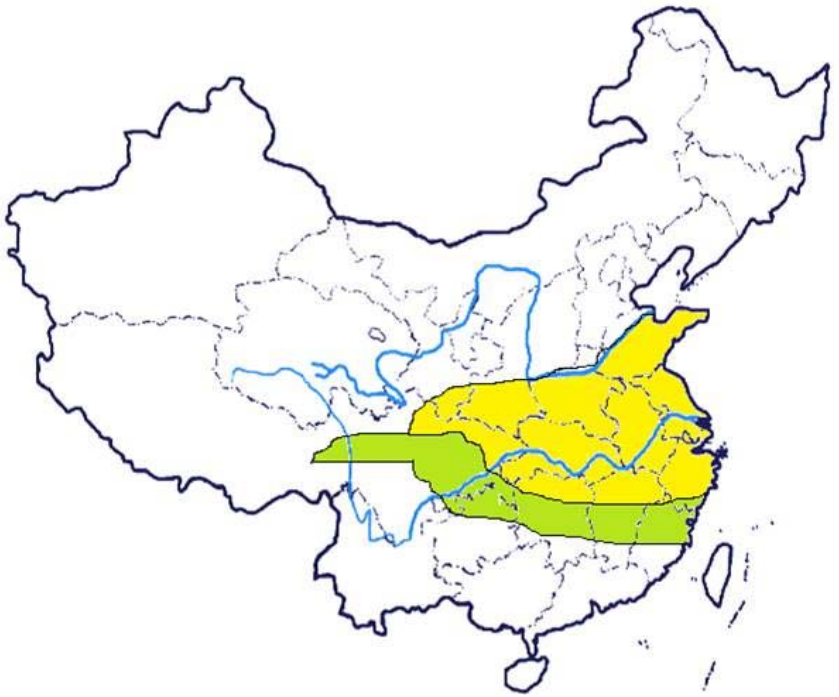
In fact, bamboo forests provide superior erosion control and act as a natural carbon sink. New plantings have been successfully introduced to depleted environmental areas that have been damaged by overharvesting of trees, or chemical-intensive agricultural use. New growth in these previously unusable areas provides a harvestable resource for nearby communities within 10 years.

The many benefits of bamboo-based industries, coupled with a rising demand for the natural beauty of bamboo products worldwide, saw global trade of bamboo products increase 600% between 1990 and 2011.

Moso Bamboo

The type of bamboo best suited for the production of building products is a timber producing bamboo, *Phyllostachys pubescens*, also known as *Phyllostachys edulis*. "*Phyllostachys*" means "leaf spike."

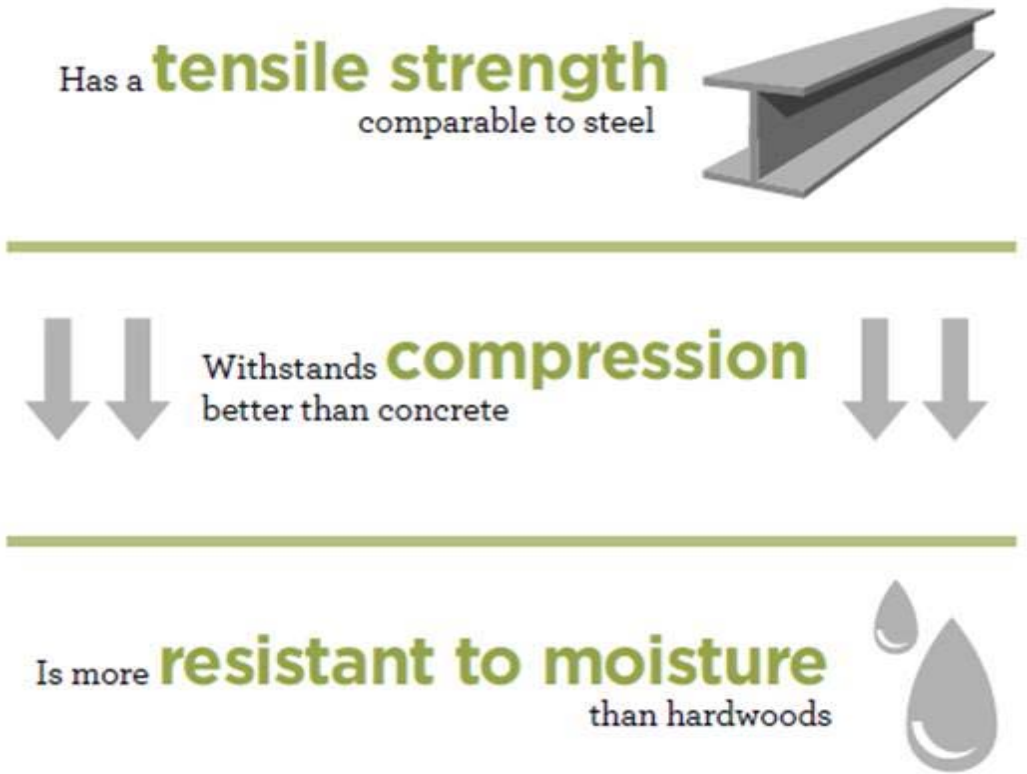
This particular sub-species of bamboo is known as *mao zhu* in Mandarin Chinese and is native to China and Taiwan. However, the plant is most commonly referred to in the West by its Japanese name—*Moso*.



The two primary growing zones for Moso bamboo in China are represented above. These growing regions span climatic zones from sub-tropical to semi-arid. Moso is the dominant, naturally-occurring sub-species in the yellow area in the North, where mountain-grown bamboo propagates naturally with little, if any, human assistance. The green region in the South is known as the "Bamboo Sea," and is largely composed of managed plantations.

Moso Bamboo

Bamboo timber species, such as Moso, perform equal to, or better than, standard hardwood and softwood when used as building products. Bamboo has about the same strength-to-weight ratio as steel in tension, has a greater compressive strength than concrete, and in its natural form, is more resistant to moisture than hardwoods.



Domestic Bamboo Industry

There were only eight companies supplying bamboo flooring to the North American market in 1997. That number is well over 200 today.

Due to the enormous market demand, one innovative company launched a new venture in 2011 to re-develop the agricultural black-belt region of Alabama by establishing a domestic bamboo industry where many former cotton fields have sat fallow for decades.

Their efforts include both cultivation of a variety of bamboo sub-species, including Moso, and the manufacturing facilities required to process and commercialize the raw materials. Domestically produced bamboo products are expected to be available by 2025.

Understanding Grain & Pattern in Bamboo

Traditional Style

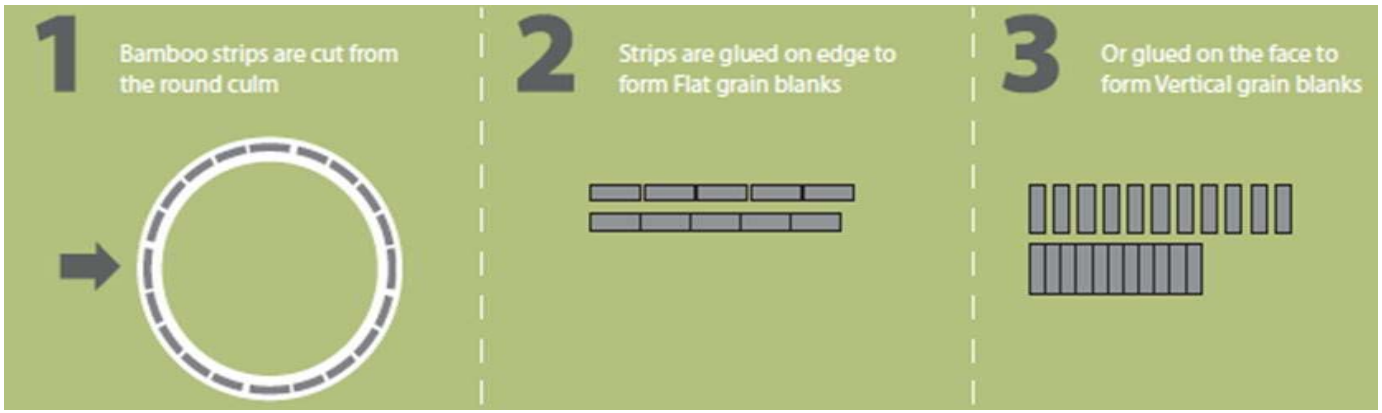
When most people think of bamboo as an interior finish, they think of something that looks like this:

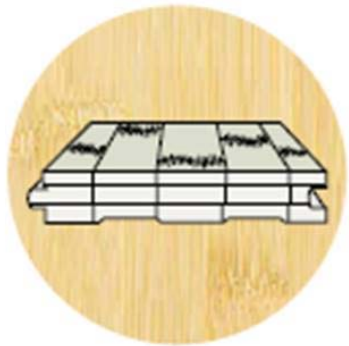
These styles represent what is known as the “traditional” look. Traditionally designed bamboo materials became widely available in North America in the early 1990s, and are readily identifiable as bamboo due to the visible presence of the bamboo nodes or “knuckles” in the material.

Traditional bamboo design comes in two basic colors—natural and caramelized—and two grain patterns—vertical or horizontal.

Traditional Style: Manufacturing Process

To achieve this look, the round bamboo culm is slatted into thin strips. These strips are already a “natural” color. To darken the slats into a “caramel” color, the strips are placed in an autoclave and heated, which literally cooks the sugars in the fiber and caramelizes them into a nice medium brown. Strips are then laminated together either along their narrow, or along the wide, edges as shown below.





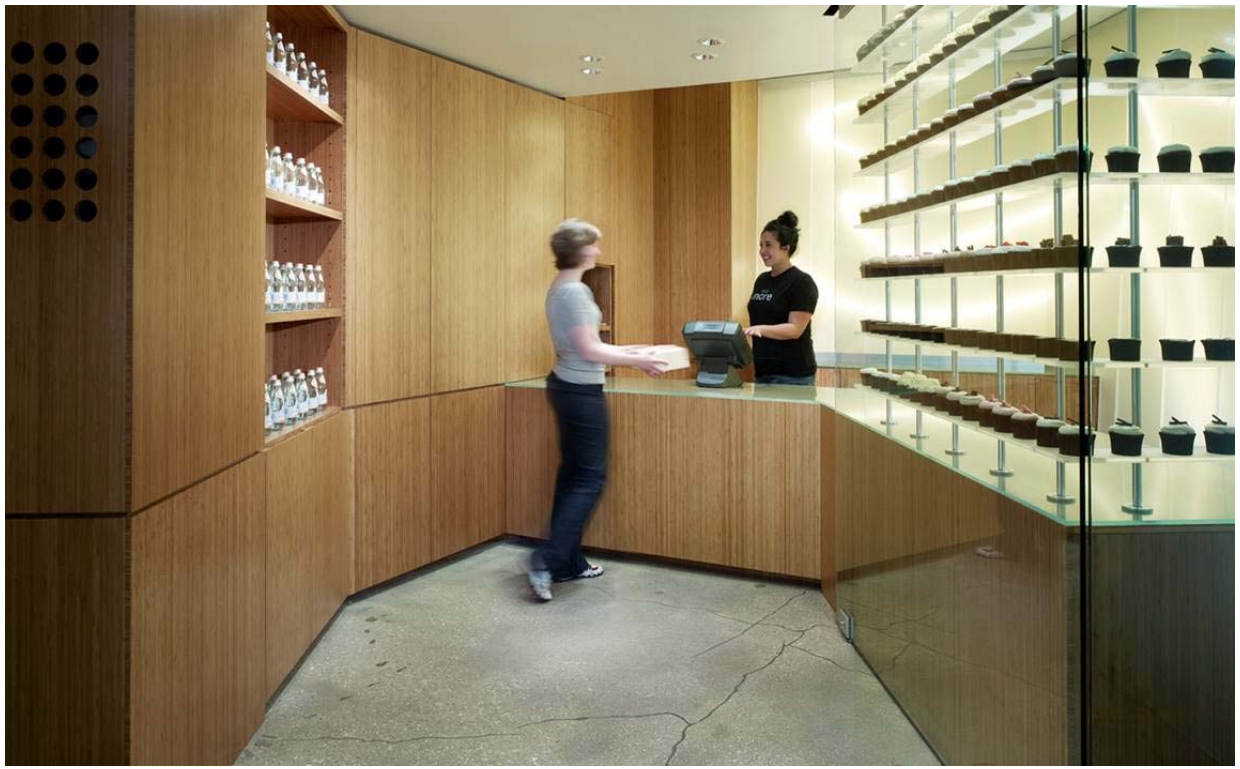
Horizontal Grain

Vertical Grain

Because multiple strips have been designed and manufactured into a single piece, these products are technically engineered; however, the end product performs comparably to a solid hardwood and is considered a solid product by the bamboo industry.

Traditional Style: Aesthetics & Design

The linear grain pattern found in traditional bamboo is often associated with a “zen” look. It pairs well with clean, contemporary design while still bringing a warm, natural element into the mix. This material is often chosen for commercial projects for just this reason, as in the example below, where vertical grain caramelized paneling has been used for this cupcake retail location.



Strand Bamboo

The other primary type of bamboo is strand bamboo. Strand bamboo products represent a leap in material innovation and first made an appearance around 2005. This product is produced via an entirely different method where the bamboo culms are shredded rather than slatted. The shredded bamboo is combined with adhesives and bundled into a mold, which is then put under immense pressure, resulting in a solid sheet of material.

The classic appearance of bamboo “knuckles” can still be seen to some degree in the finished product, although far less so than in the traditional designs. Instead, the impact of the shredded material on the grain and appearance of strand bamboo results in a product that can look remarkably similar to traditional hardwoods, but is much harder.

Cross-Section: Flooring Plank Made of Solid Strand Bamboo

Strand Bamboo

Since its introduction to the market, strand bamboo has come to dominate the bamboo space and currently represents almost 80% of bamboo sales.

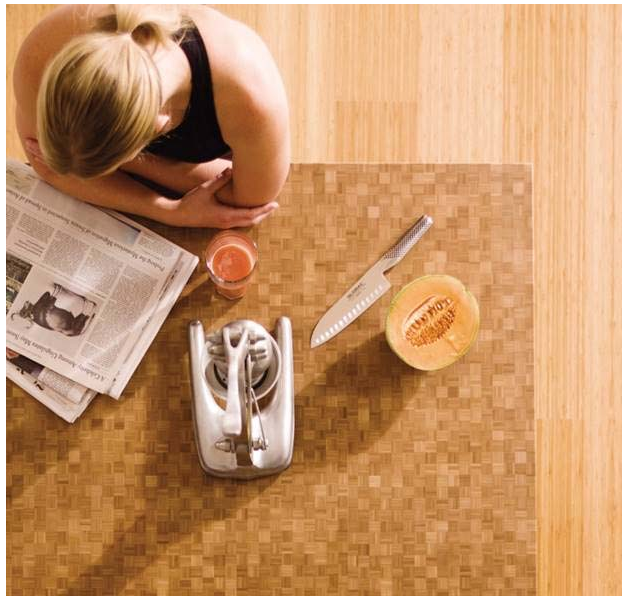
Its hardwood look-alike grain pattern coupled with its compelling environmental story make strand bamboo a drop-in alternative for traditional hardwoods.

Bamboo Countertops

Bamboo exhibits material properties similar to that of a solid hardwood, and as such, standard woodworking techniques can be employed to achieve various looks. For example, bamboo countertops are a growing trend, and several styles are widely available.

The photo on the left shows a bamboo countertop where a layer of strand bamboo has been laminated as a cross-ply between the two outer layers of traditional material.

The photo on the right shows a parquet butcher block countertop made from bamboo.



Texture & Finish Options

In addition to grain and pattern, when choosing a bamboo product to include in your design, you can also select from among various texture and finish options.

Flooring – Handscraped

Flooring – Whitewash

Flooring – Chocolate Stain

Veneer – Multi-Color

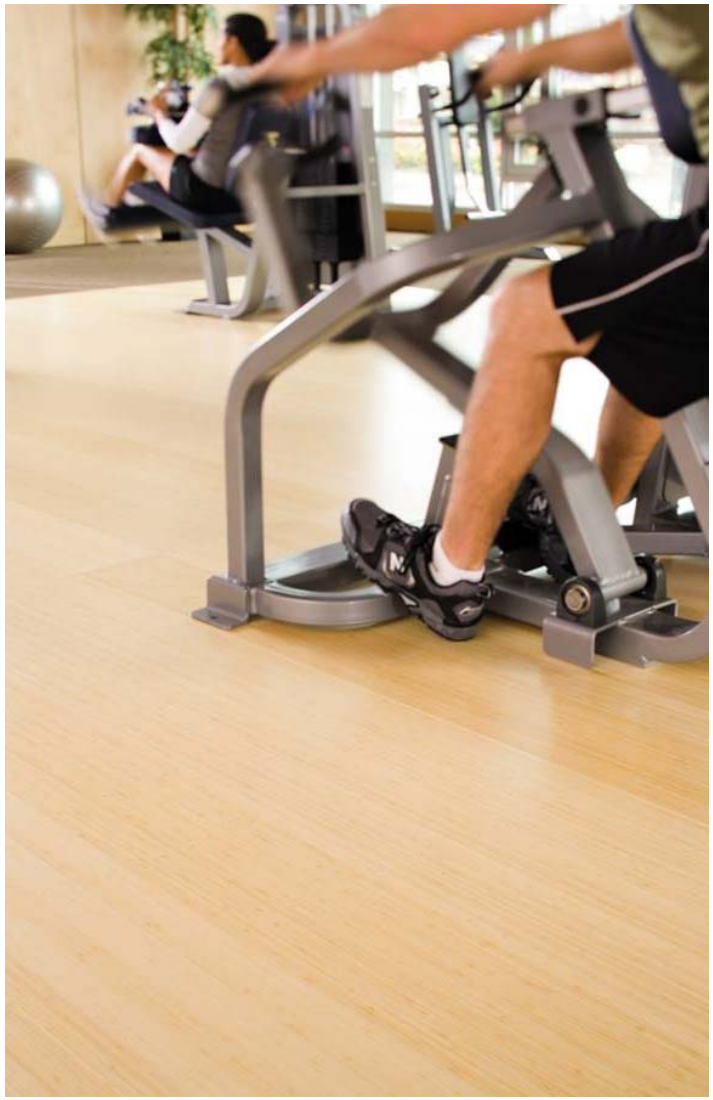
Performance & Durability

Standard Measures of Durability

Bamboo flooring is often specified for commercial installations, in part due to its renowned durability and reliable performance.

Some key standard measures of durability and performance in hardwood products are:

- **The Janka Score:** A measure of hardness and resistance to denting.
- **Dimensional Stability:** An understanding of how a natural wood product expands and contracts in response to its environment.
- **Wear:** How the installed product will hold up to a combination of factors that it will encounter on a regular basis, which may include: scratching, denting, UV durability, stain resistance, etc.



The Janka Hardness Test

The Janka hardness test determines the resistance of wood to denting and wear by measuring the force required to embed a small steel ball to a certain depth.

Because the same test under the same conditions can be applied to all types of wood, the resulting hardness “score” can help us understand how hard or durable certain wood species are compared to others.

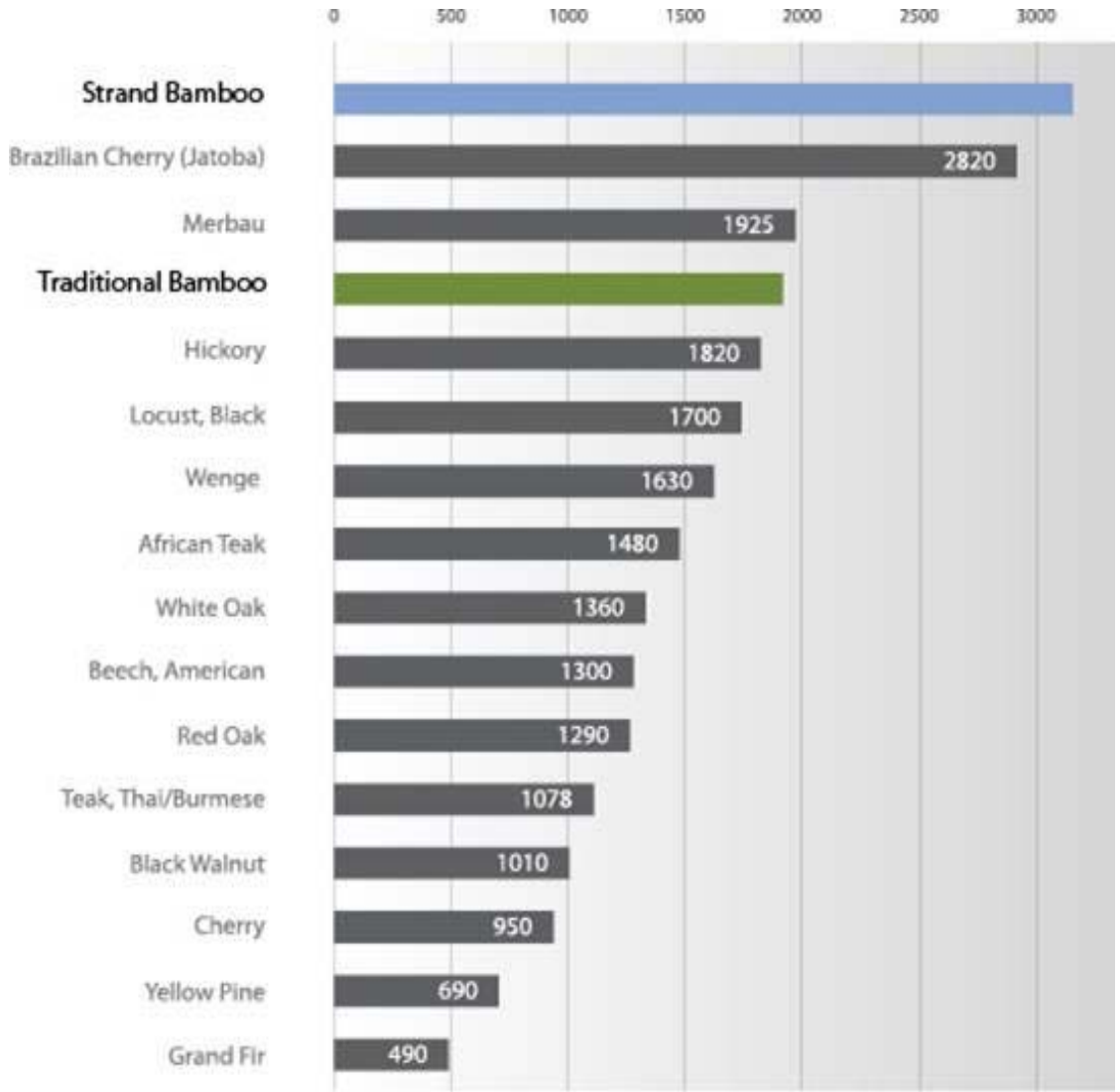
0.444" steel ball embedded halfway into wood sample

Janka Hardness Test
Measures force needed to embed ball

Janka Scores

This chart shows some standard Janka scores for various types of wood species. The units of measurement indicate the pounds-force required to embed the steel ball to the required depth—the more pounds-force used, the harder the material.

Brazilian cherry, long considered to be the gold standard of hardness and durability for wood flooring, is near the top, right below strand bamboo. In fact, both strand and traditional bamboo outperform almost all other hardwood species.

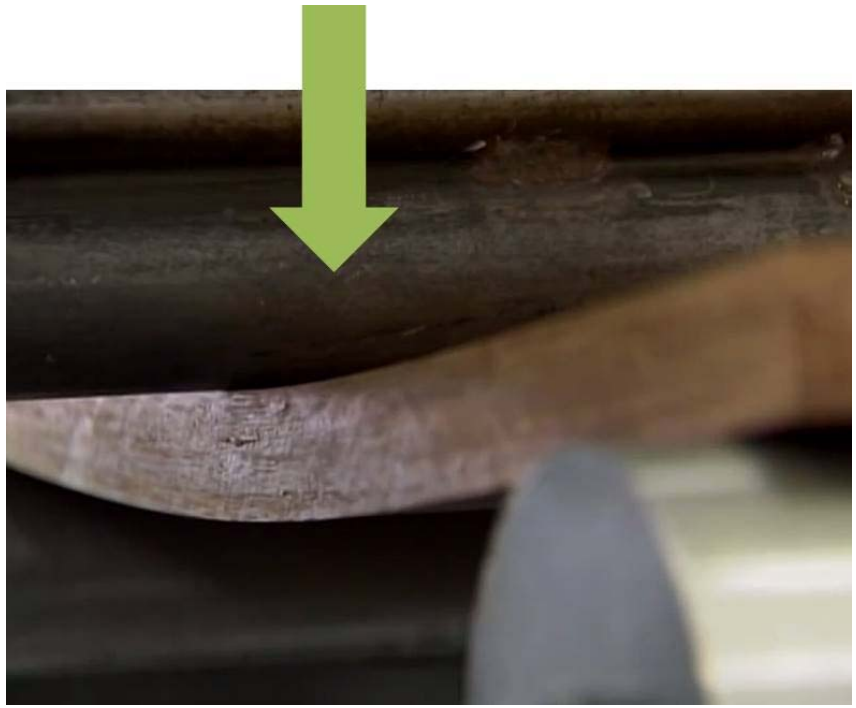


Durability: Bamboo vs. Oak

Not only is bamboo harder than oak, but it is also more durable, as this second test shows. While the oak plank failed this test under 4700 lbs of pressure, the strand bamboo held out until 5600 lbs of pressure had been applied. The bamboo continued to flex 19% longer than the oak.

Considering the hardness and durability characteristics of a wood before specifying is important because you want to select a product that is going to perform within the conditions of the installation. A harder, more durable product is going to look good and last longer without needing to be replaced.

Another standard test measures the pounds-force that can be applied to the middle of a board of wood before the material fails. In the photo below, a machine is exerting downward pressure on a 1"-thick plank of strand bamboo.



Dimensional Stability

It's a commonly known fact that wood and wood products expand (swell) and contract (shrink) depending on the conditions of the surrounding environment. This expansion and contraction occurs when wood exchanges moisture with the air. The amount of moisture exchange that occurs depends on a number of factors:

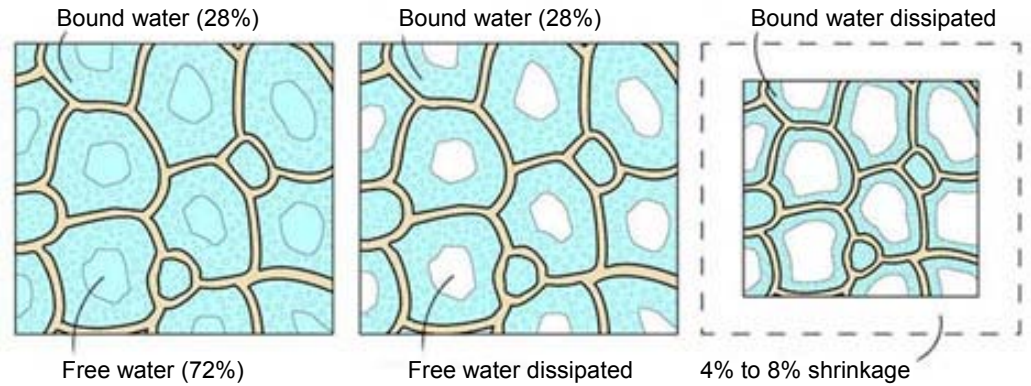
- Relative humidity and temperature of the air
- Current amount of water in the wood
- Presence of protective coatings (varnish, lacquer, paint, etc.)
- Density of the wood

Dimensional Stability: *The degree to which a material maintains its original dimensions when subjected to changes in temperature and humidity.*

Relative Humidity (RH): *The ratio between the actual amount of water vapor present in the air and the saturation point at the same temperature. The RH is 100% when it is raining.*

Dimensional Stability

This dimensional change in the product occurs as the volume of the fiber's cell wall grows or shrinks depending on the amount of bound water it contains.



As a general rule of thumb, wood expands as it gets warmer and shrinks when it is cooler.

Day-to-day changes in environmental relative humidity and temperature generally do not have a significant impact on wood products; however, lasting seasonal changes can trigger dimensional change. The rate at which wood products exchange moisture with the surrounding environment can be slowed down when protective coatings are used. However, they cannot stop the process altogether.

Wood products should be acclimated to the environments in which they will be installed prior to fabrication or installation to achieve best performance.

Dimensional Stability

Like wood, dimensional change in bamboo products most often occurs across the width of the product, rather than the length. The known dimensional change coefficient of bamboo and other wood species can be used to predict how much dimensional change to plan for.

Standard change coefficients for tangential milling profiles of popular species are listed in the chart to the right. This number tells us how much a 1"-wide piece of material will swell (across the width) for each percentage point change in the moisture content of the material. For example, a 3'-wide piece of oak will expand 0.14256" when the moisture content of the material increases by one percentage point, while traditional bamboo of the same width will change by less than half that (0.05868"), and strand bamboo will change hardly at all (0.03096").

Species	Change Coefficient
Strand Bamboo	0.00086
Traditional Bamboo	0.00163
Teak	0.00186
Pine	0.00263
Brazilian Cherry	0.00300
Maple	0.00353
Red Oak	0.00396

Dimensional Stability

To put it another way, this data shows that traditional bamboo is more than twice as dimensionally stable as oak, and strand bamboo is almost five times as stable as oak, largely due to its density.

Understanding dimensional change and anticipating its impact will help you to have a successful installation.

Bamboo product stability, in addition to hardness and durability, is another reason why commercial use of bamboo products is growing at a rapid pace.

Species	Change Coefficient
Strand Bamboo	0.00086
Traditional Bamboo	0.00163
Teak	0.00186
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Maple	0.00353
Red Oak	0.00396

Wear

Testing data on metrics, such as hardness, durability, and dimensional stability, are valuable in helping you to narrow down the field on which product to select. However, it is also important to understand how exactly that product is going to perform and wear long-term once it is in the installation environment.

For this purpose, slightly more subjective tests are used, such as the ones employed by Consumer Reports. Take hardwood flooring for example: each year, Consumer Reports releases their annual hardwood flooring report, which tests and ranks products in the following categories: Foot Traffic, Scratches, Stains, Dents, Sunlight (UV).

In both 2013 and 2014:

- **2** of the **Top 3** Solid Hardwood Floors recommended by Consumer Reports were bamboo
- **1** of the **Top 3** Engineered Hardwood Floors was bamboo

All-in-all, **half** of the top recommended products two years in a row were bamboo—more than any other species!

Commercial Application Example

It is the combination of beauty and performance that makes bamboo a trusted interior finish for commercial applications around the globe.

LYFE Kitchen Restaurant

- Bamboo Use
  - Flooring
  - Paneling
  - Countertops
- Locations in California, Nevada, Colorado, Texas, and Illinois

Commercial Application Examples

Rio Tinto Soccer Stadium, Utah
Strand Bamboo Flooring

The Oyster Box Hotel, South Africa
Strand Bamboo Flooring

Commercial Application Example

Yale University, Connecticut
Traditional Bamboo Flooring and Paneling

Choosing High-Quality Bamboo Products

The data included in this presentation has been procured from quality manufacturers of bamboo products, meaning those companies have been in business for more than 10 years, hold good ranking with the Better Business Bureau, and are headquartered out of North America.

When choosing a product from a company that meets these criteria, you are likely to get a high-quality bamboo product that will perform as discussed. However, since there are no national quality standards for bamboo products the way that there are for hardwood, it is important to recognize that: NOT ALL BAMBOO IS CREATED EQUAL.

Currently, there are many low-quality bamboo imports available in the North American market that do not perform as well as they should, primarily due to poor-quality raw materials and inferior manufacturing practices. In this instance, the old adage is true that, “You Get What You Pay For.”

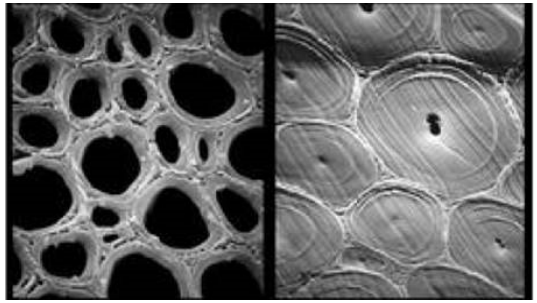
Two things that quality manufacturers do to ensure that their products are the best of the best are to use only high-quality raw materials, harvested at the right time, and invest in advanced manufacturing technologies that result in superior products.

Optimum 5.5 Bamboo

Moso bamboo grows very fast, and a new plant will reach its full height in the first year. However, a one-year-old culm only contains 40% of the total mass, or dry matter, of a mature culm that is between five and six years old, when the plant has reached its peak density and is ready for harvest.

As you can see in the photo, the immature young culm does not yet have the robust cellular structure of a mature culm. If bamboo products are made from culms that are harvested too young, the resulting product will likely underperform. This is why quality manufacturers use Optimum 5.5 designated raw materials—bamboo harvested at five-and-a-half years and no younger.

To keep track of the age of the culms in the forest, new culms are marked with a date stamp in their first year.



Electron microscope photos of *Phyllostachys viridiglaucescens* at one year (left) and 12 years (right) show how the loose network of fibers gains density as it ages.
Photos: Walter Liese, Ph.D., University of Hamburg's Institute of Wood Biology

Culm: In botanical context, "culm" originally referred to a stem of any type of plant. It is derived from the Latin word for "stalk" (*culmus*), and in this context specifically refers to the harvestable portion of the bamboo plant.

Quality Manufacturing Processes

This photo shows the cross-sections of two different traditional bamboo flooring planks made by two different manufacturers. You can clearly see that the lamination lines in the product from Brand “Y” are superior to those in the product from Brand “X”.

Brand “X”   **Brand “Y”**

Not only do bamboo manufacturers need to ensure that they are sourcing quality Optimum 5.5 bamboo and quality adhesives, they must also take care to precision-mill the bamboo slats used to form the end material. Once a bamboo culm is harvested, it is then slatted into thin strips to make traditional material. These strips are then milled to remove the waxy green outer skin and the soft, pulpy interior edge. Some manufacturers may try to cut corners and lower their costs by milling off less of the soft, pulpy inside edge, which can result in an end product that underperforms.

Once milled, slats should then be moisture balanced and then milled again to ensure that all slats are perfectly square so that they will fit together at perfect right angles. Also, at this stage, quality manufacturers will cull out any off-spec slats so that they do not make it into the final product. Once the slats have been assembled, the end product is then moisture balanced a second time. This final step ensures that the end product arrives to the customer in a stabilized condition, ready for either fabrication or installation.

Cold Press Strand Bamboo

There are two primary methods in use today for the manufacture of strand bamboo: cold press and hot press.

Cold press strand bamboo is made from a combination of shredded bamboo fiber and resin, which is compressed into 100mm-thick blocks and cured.

If not cured evenly and correctly, flooring planks milled from the interior of the block can have a higher moisture content and lower density than those milled from the outer edges, resulting in possible product failure, such as cupping or warping.

Cold Press

Hot Press Strand Bamboo

Quality manufacturers use an alternate method known as hot press, which was introduced in the early 2000s.

Hot press strand bamboo is manufactured by taking the mixture of shredded bamboo fiber and resin, assembling it into 48mm-thick sheets, and applying over 2,000 tons of hydraulic pressure and heat on all sides. This hot press method results in consistent moisture content throughout the entire sheet of material, as well as increased dimensional stability in flooring planks and panels milled from the strand bamboo sheets.

Hot press strand bamboo consistently outperforms products milled from cold press strand blocks.

Hot Press

Bamboo Forests: A Natural Carbon Sink

Carbon Emissions

Carbon dioxide (CO_2) is a greenhouse gas. The presence of high levels of CO_2 in the atmosphere contribute to increased temperatures at the Earth's surface.

When plants photosynthesize, they take in CO_2 from the air and emit oxygen (O_2). They then convert the carbon into the carbohydrates that make up their structure, essentially "locking up" the carbon in the form of biomass and preventing it from going back into the atmosphere.

Because plants capture and "lock up" carbon, forests play an important role in helping to keep global temperatures in check. Correspondingly, deforestation is a major source of carbon emissions and as of 2008, was the third largest source of global greenhouse gas increases after the burning of coal and oil. This is due to both the loss of forested acreage that would otherwise have helped to capture carbon, as well as to the decomposition of biomass, i.e., the stumps and roots of felled trees that release their captured carbon back into the atmosphere as they biodegrade.

Alternatively, when a bamboo culm is harvested, its networked root structure does not biodegrade, but rather continues to live on, keeping carbon locked up.

Moso Bamboo Carbon Distribution

Moso bamboo is 47.5% carbon by weight, and that locked-up carbon is distributed within the plant as follows:

- Culm: 46%
- Roots (Rhizome): 42%
- Branches: 7%
- Leaves: 5%

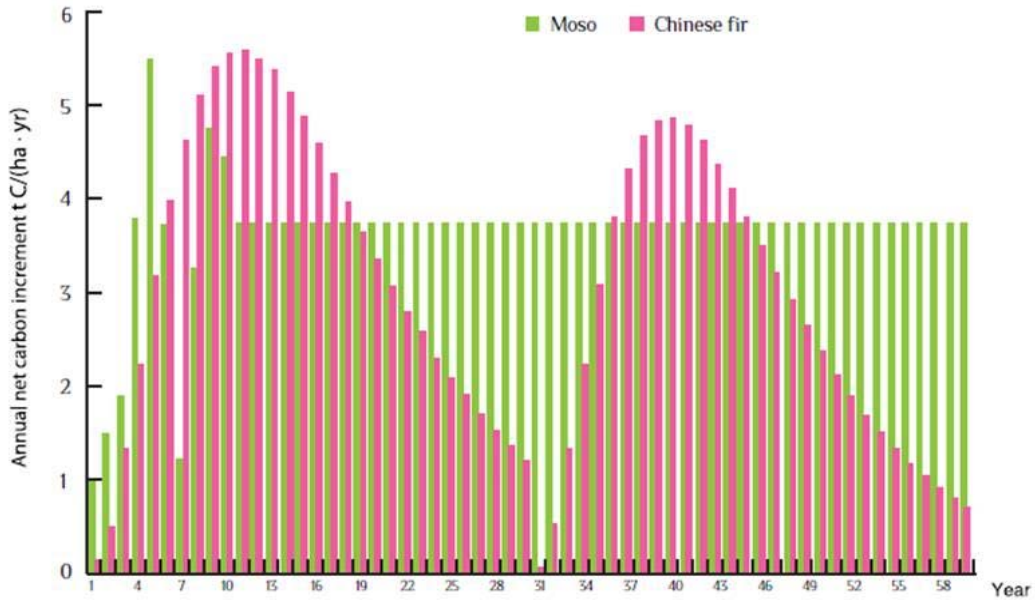
This means that even when a bamboo culm is harvested as a source of raw material, 42% of the carbon that particular plant captured remains locked in the collective root system of the bamboo forest.

Bamboo Rhizome

Rhizome: The subterranean portion of the bamboo plant that sends out roots and shoots. Rhizomes grow just under the soil's surface, and can expand laterally outward to send up new shoots. Some examples of plants that reproduce through rhizomes include bamboo, ginger, hops, asparagus, iris, and orchids.

Carbon Sequestration: Moso Bamboo vs. Fir Trees

A study comparing the carbon sequestration properties of Moso bamboo to fir trees found that the two plants, when grown for commercial production, sequestered about equal amounts of carbon after 30 years. However, fir plantations are clear-cut every 30 years, while bamboo forests are selectively harvested, providing a consistent habitat that brings additional benefits. Also, fir trees can only be grown on the same land for two, 30-year cycles before they must be relocated, due to soil and nutrient degradation. Bamboo forests are sustainably managed through selective harvesting, require no chemical inputs to encourage growth, and provide a reliable and consistent form for carbon capture.

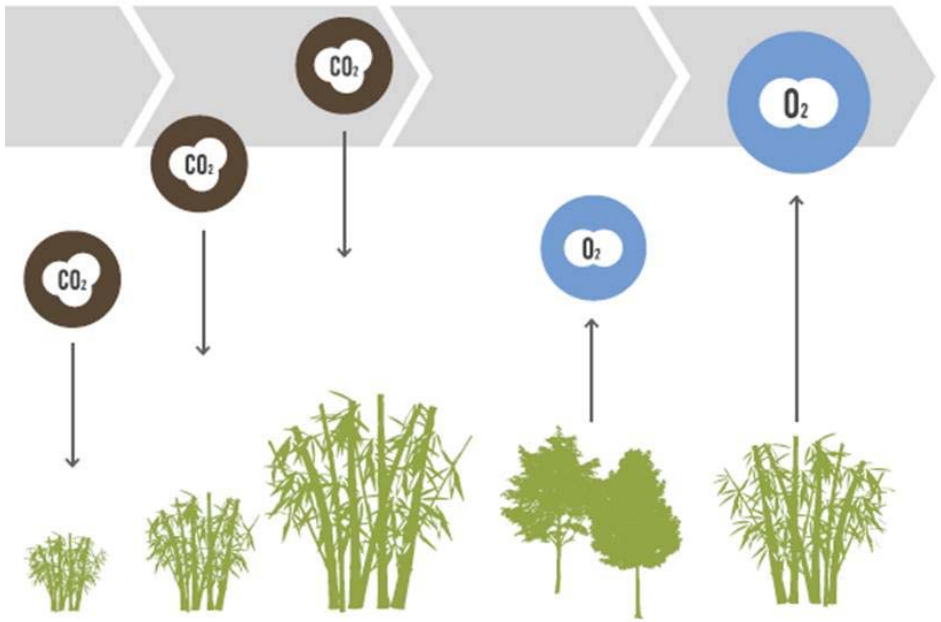


Carbon Sequestration: Moso Bamboo vs. Hardwood

The comparison between Moso bamboo and fir, however, is a bit like apples and oranges, since fir is a softwood and Moso bamboo is harder than traditional hardwoods.

To get a more accurate picture, we must consider how bamboo's ability to sequester carbon compares to hardwood trees. In this case, we find that bamboo locks up 60% more carbon per unit than hardwood trees AND bamboo's leafy canopy releases 35% more oxygen back into the atmosphere per unit than hardwoods.

On average, one pound of bamboo removes 1.67 pounds of carbon from the atmosphere. When the bamboo culm is harvested and turned into building products and other finished goods, the carbon remains locked up in the products until they either naturally decompose or are burned.



Myth-Buster

It is a common myth that the necessity of shipping bamboo products made in China to North America negates the positive environmental impacts that these products represent.

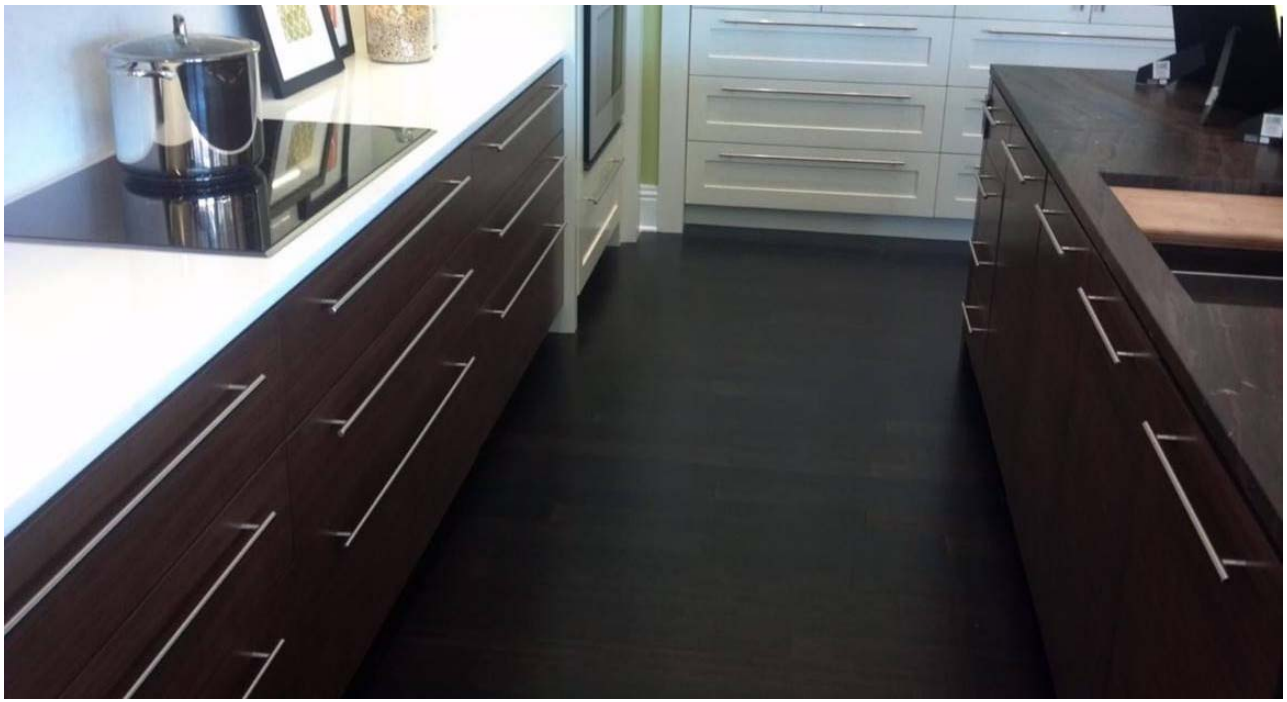
Here are some facts:

- A typical ocean transport container filled with finished bamboo products holds about 38,000 lbs of pure bamboo, which represents 67,000 lbs of sequestered carbon (1.67 lbs of carbon per 1 lb of bamboo).
- These products will spend at least 75% of their journey via ocean cargo, which is 50–70% more fuel efficient than transport by truck.
- Most products going to final destinations within North America will spend at least half of their overland journey on a train, which uses 76% less fuel per mile than transport by truck.
- When the bamboo product arrives at its ultimate destination, it will still be a carbon negative product, even accounting for all of the carbon that was spent to transport it.

Considering that many hardwood floors made from traditional, domestic wood sources are manufactured overseas as well, which requires double the freight—out of the country and then back in again—bamboo truly does offer an environmentally preferable product.

Zero Energy America (ZEA) Project

Bamboo flooring was used in the Zero Energy America (ZEA) project (pictured below) in part because of the high-density carbon properties of bamboo. ZEA designed and built 14 homes in South Florida that were designed to operate without monthly energy bills. Bamboo was selected because the back-story of the product closely aligned with the goals and ideals of the development.



Zero Energy America: Strand Bamboo Flooring with a Dark Stain

Zero Energy America (ZEA) Project

Zero Energy America: Strand Bamboo Flooring with a Dark Stain

A Rapidly Renewable Resource

Rapidly Renewable Resources Defined

"Renewable resources" are natural materials that can self-replenish, either through biological reproduction or other naturally occurring processes.

As defined by the United States Green Building Council (USGBC), a "rapidly renewable" resource is one that can be cyclically replenished in under 10 years.

Since Moso bamboo, as used in building materials, is harvested when the plants are between five and six years old, bamboo is considered a rapidly renewable resource.

About half of all non-renewable resources being used today are used in the building sector. The USGBC's Leadership in Energy and Environmental Design (LEED®) program has therefore provided incentives for increasing the use of rapidly renewable resources to aid in reducing the use of finite raw materials.

LEED: Bamboo Products

In November 2002, interior finishes made from bamboo were classified by the USGBC as an “environmentally preferable material” under the LEED v.2.1 standard, qualifying for the rapidly renewable materials credit.

More recently, under LEED v2009, all bamboo products qualify for Credit MR 6 – Rapidly Renewable Materials.

The most recent LEED standard v4, has shifted the language of the applicable credit MRc3 to “Building Product Disclosure and Optimization – Sourcing of Raw Materials.” This change is intended to take a more holistic look at a product’s overall lifecycle impact. To qualify, rapidly renewable materials must now also meet the Sustainable Agriculture Network Standard currently in review. Products made from rapidly renewable materials that meet the criteria are valued at 100% of their cost for the purposes of credit achievement calculation.

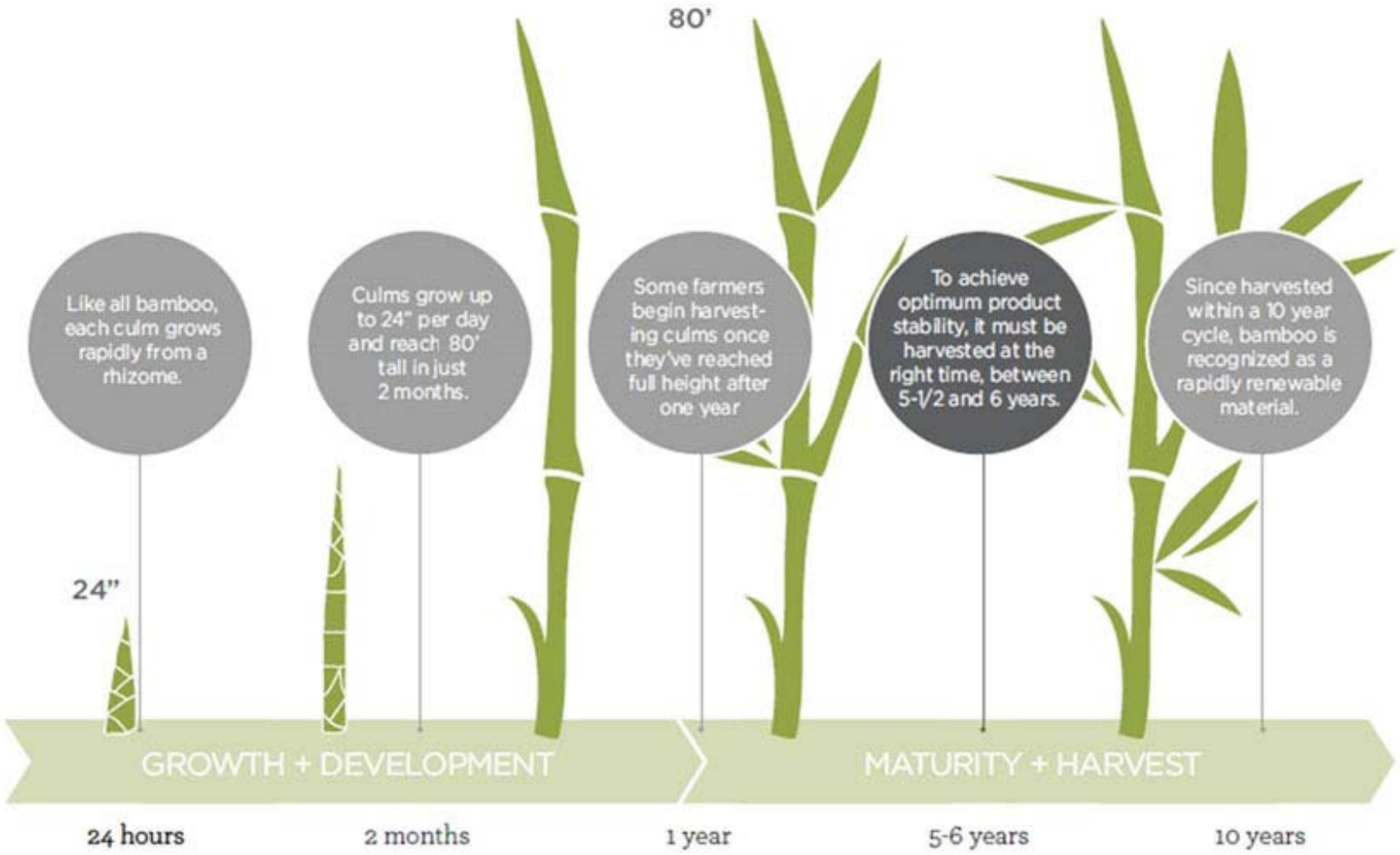
Average Yield by Species

The fact that bamboo is rapidly renewable means that it can supply more raw material faster to a growing construction and remodeling industry than traditional timber resources.

The chart below compares the average yield and growth cycles of natural mountain-grown bamboo to domestic maple and red oak—the two most commonly used hardwood species throughout North America.

Species	Moso Bamboo	Hard Maple	Red Oak
Harvest Cycle	5–6 years	80–100 years	80–100 years
Harvest Method	Selection Harvesting	Selection Harvesting	Selection Harvesting to Patch Clear-cutting
Above Ground Harvestable Volume (meter/hectare/year)	6.6–8.8	2–3	2–3
Annual Yield vs. Domestic Maple	3.3–4.4	1	1
Herbicide Use?	No	No	Yes
Number of Harvest Cycles Over a 90-Year Period	16	1	1

Moso Bamboo Lifecycle

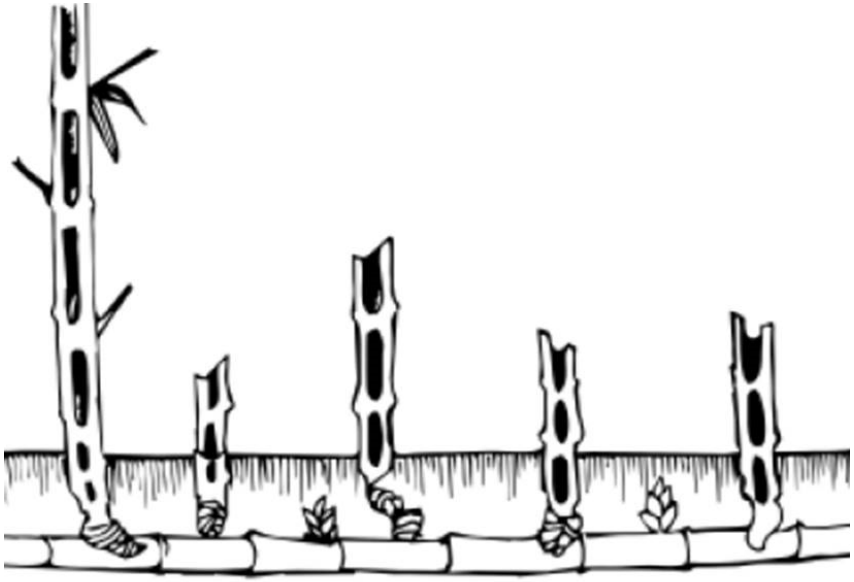


Clumping Bamboo & Running Bamboo

There are two primary groups of bamboo sub-species—clumping bamboos and running bamboos.

Clumping type bamboos send up shoots in discrete groups within a contained perimeter that grows outward a few inches every year.

Moso is a running bamboo. Running bamboos feature linear, underground root systems that rely on rhizome buds to either send up a new bamboo shoot or to extend a new underground rhizome branch. Over time, this extensive and networked root system, which exists just a few inches below the soil's surface, forms a very stable "mesh" that stabilizes soil and helps prevent erosion.



Erosion Control & Soil Preservation

Running type bamboos have been used around the globe for the purposes of erosion control and soil preservation and have significantly helped reduce runoff on steep slopes. In commercial forests where harmful harvesting practices such as clear-cutting are used, bamboo provides a profitable alternative. In 1998, the Chinese government banned all timber harvesting after a summer of heavy rainfall led to severe flooding, due in part to slopes exposed from timber production. Strategic use of bamboo rather than timber in these high-risk areas could have mitigated the risk of natural disaster while still providing an economic return.

In India, an area of land that had traditionally been mined for clay for brickmaking over the course of generations was nutritionally depleted and had lost most of its vegetative cover, and the nearby village was experiencing regular sandstorms. The land was rehabilitated through managed bamboo plantations and after just five years, the water table has risen by seven meters, residents can successfully farm again, and the dust storms have gone.

Sustainable Harvesting Practices

Because local families rely on bamboo forests year after year for their livelihood, these forests are actively managed for a sustainable and balanced delivery of social, ecological, and economic products and values. They are tended with care to ensure the longevity and vitality of the forest ecosystem. In order to protect the root system that lies just below the surface of the soil, harvested culms are carried out by hand and manually loaded onto waiting trucks. If any heavy machinery were to drive into the forest, the weight of the vehicle would damage the root system and jeopardize future harvests. Bamboo culms are not clear-cut, but selectively harvested. In one acre, there are approximately 1,000 culms and only 20% (about 180 culms) are harvested in a given year.

Forest Stewardship Council (FSC)

Bamboo products are inherently compliant with Forest Stewardship Council (FSC) practices due to the non-additive and low impact growth and harvesting methods, but many brands still choose to pursue official FSC certification for their products. An FSC certification means that:

Forests are protected:

- Enhanced water quality standards, prohibition against harvest of rare old-growth forests, prevention of loss of natural forest cover, and stringent regulation of highly hazardous chemicals—often above and beyond local regulations.

Communities are represented:

- Public transparency of certification audits and active protection of indigenous groups' rights to forest access and use.

In LEED v2009, the use of FSC-certified products qualifies for Credit MR 7 – Certified Wood. In LEED v4, this credit is now grouped with rapidly renewables under credit MRc3 for "Building Product Disclosure and Optimization."

Rocky River Green Home

The Rocky River Green Home is a LEED Platinum remodel in Ohio that chose bamboo for both its flooring and custom cabinetry options in part due to the multiple LEED credits available.

Custom Vanity Made from Traditional Bamboo Panels

Rocky River Green Home

Bamboo Flooring in Kitchen with a Dark Stain

USDA BioPreferred® Program

Some bamboo products also qualify under the U.S. Government's USDA BioPreferred® Program. Implemented in 2002, the program is designed to promote the increased purchase and use of bio-based products. Each manufacturer must submit their products for testing in order to gain the certification. When tested, many bamboo products are determined to contain 94%–99% bio-based materials.

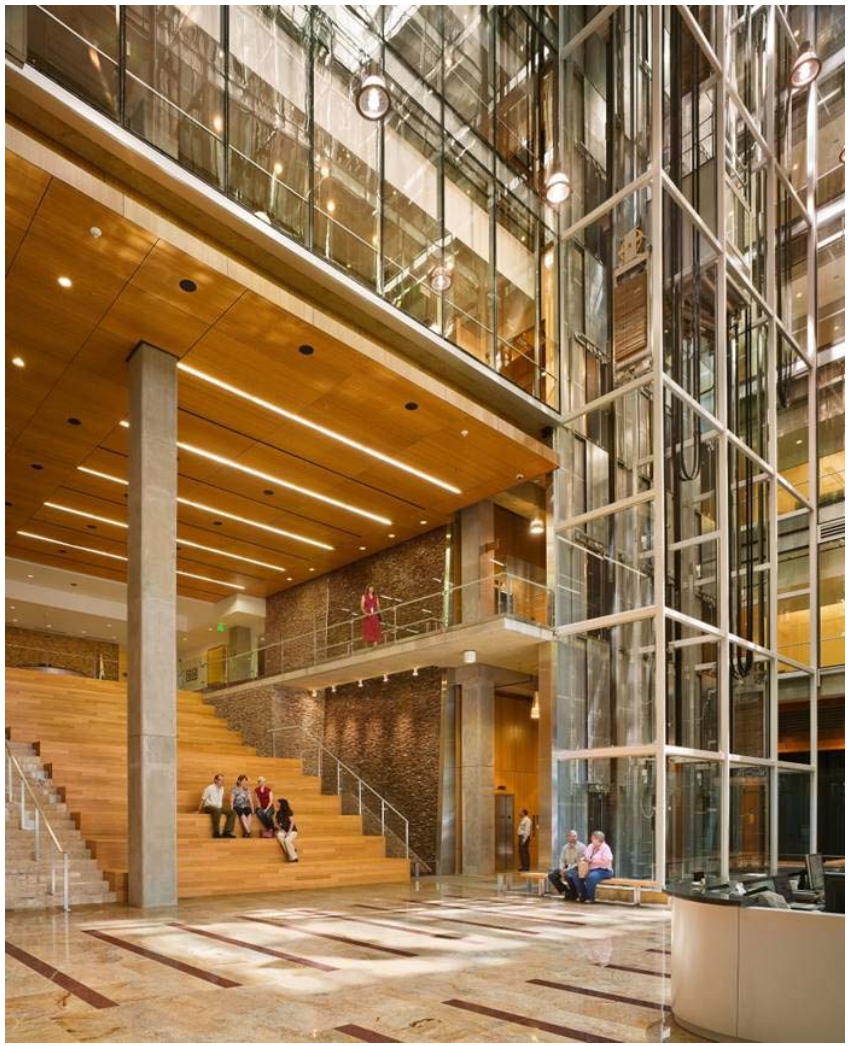
Products that are tested and certified to a minimum bio-based material content under the program qualify for preferential treatment for specification and procurement by government agencies and for government-financed projects.

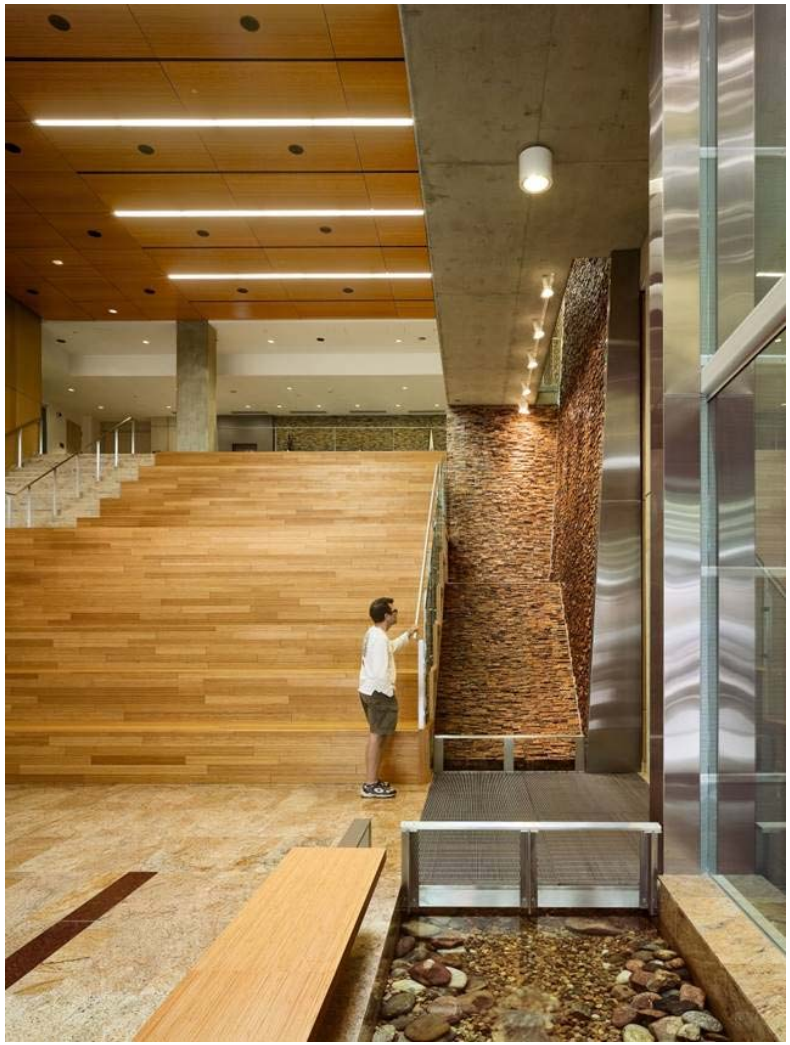
Door and Paneling Using Traditional Bamboo Veneer

Bio-based Product: Commercial or industrial products (other than food or feed) that are composed in whole, or in significant part, of biological products, renewable agricultural materials (including plant, animal, and marine materials), or forestry materials.

USDA CERTIFIED BIOBASED PRODUCT PRODUCT 99%

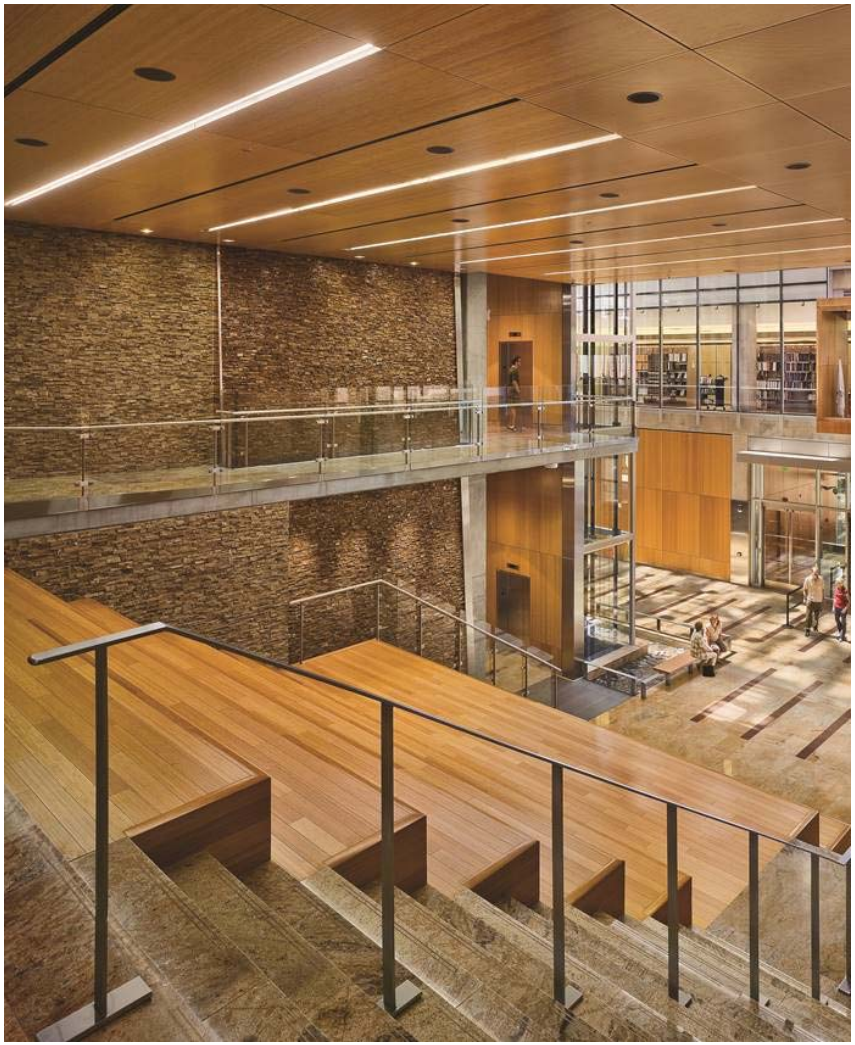
U.S. Environmental Protection Agency Regional Headquarters: Colorado

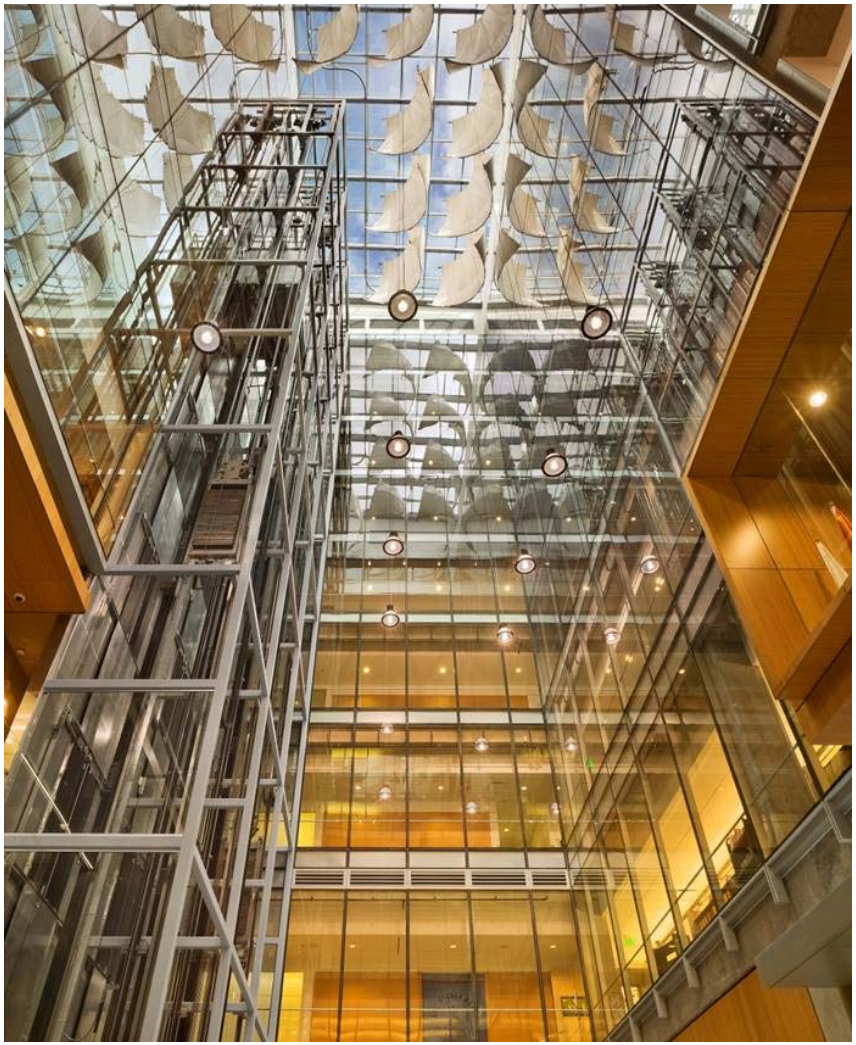




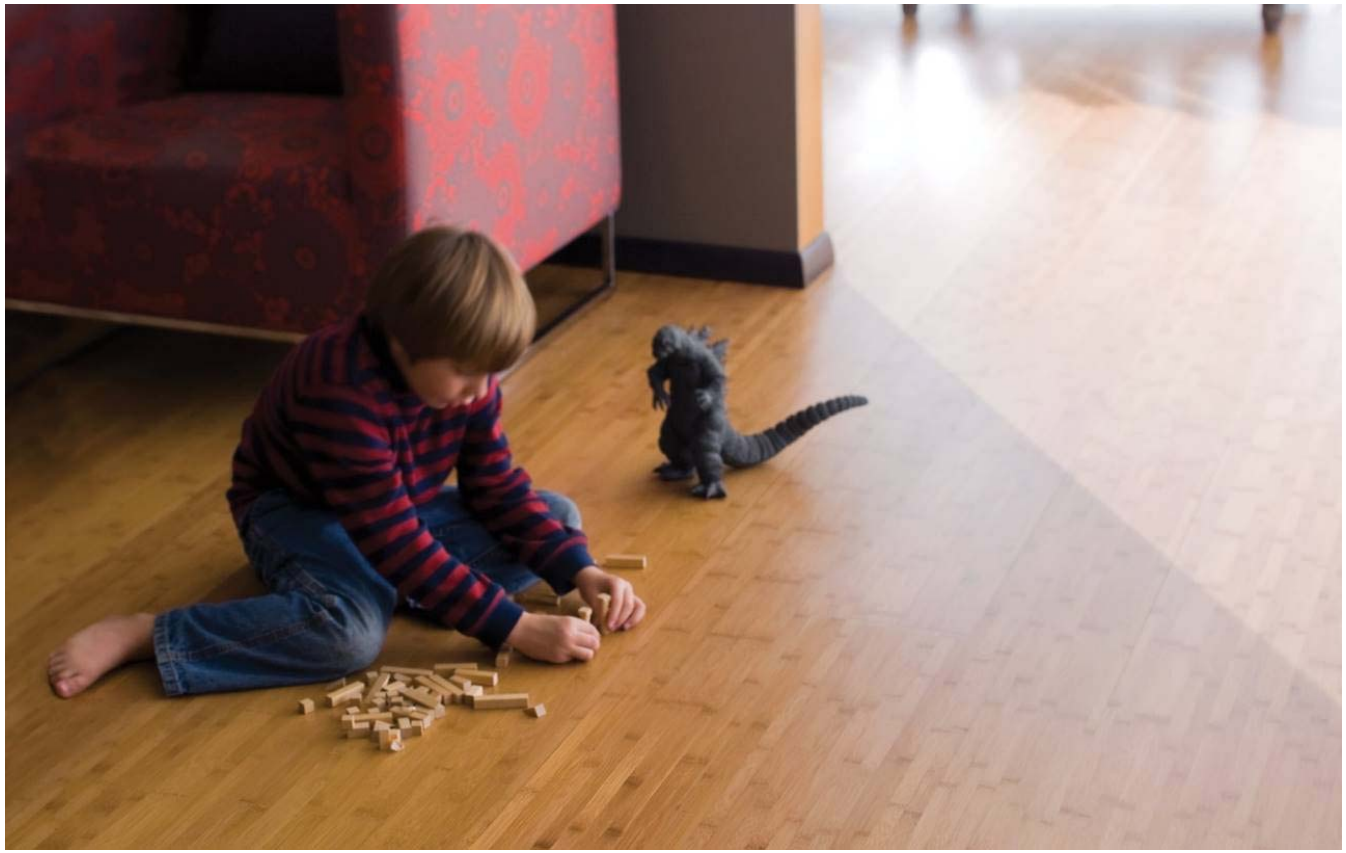
Bamboo Flooring and Paneling

U.S. Environmental Protection Agency Regional Headquarters: Colorado





Bamboo Flooring and Paneling



Human Health Impacts

California Standard 01350

Another advantage of bamboo products is that many are certified to California Standard 01350 and/or CARB Phase II for indoor air quality. Many certified products carry third-party endorsements, such as FloorScore® or GREENGUARD, both of which use the CA01350 standard as the baseline in their testing of volatile organic compounds (VOCs) to ensure that products are not off-gassing harmful chemicals. Products certified to the CA01350 standard currently meet the most rigorous testing protocol in the world for healthy indoor air quality.

VOC: Volatile organic compounds are chemicals used in the production and manufacture of many products that vaporize—turn into gas—throughout the life of those products. Think of that "new car smell." VOCs are widely documented to have negative health impacts, and concentrations of VOCs are found to be up to 10 times higher inside buildings than outside.

Poor indoor air quality has been documented as having a negative impact on mental well-being, particularly in large buildings and work environments where recycled air is the standard and occupants have little to no regular access to fresh air. This scenario is called "sick building syndrome" and has been linked to physical symptoms in occupants, including headaches, tiredness, itchiness, muscle pain, and increased psychological stress.

In an effort to ensure that building residents experience no negative health effects due to compromised air quality, building products certified to CA01350—including bamboo—contribute to either IEQ 4.3 or IEQ 4.4 under the LEED v2009 green building standard, and to credit EQc2 under LEED v4.

Top Four Indoor Air Pollutants

The top four most common indoor air pollutants as identified by the World Health Organization are listed in the chart to the right. These air contaminants have been linked to respiratory disease, including asthma, lung cancer, and mesothelioma.

The elderly, individuals with pre-existing respiratory disease, and children are at greatest risk of developing health issues due to exposure to poor indoor air quality. Children breathe in 50% more air per pound of body weight than adults, and are therefore exposed to more air contaminants overall.

Indoor air pollutant	Definition	Health impact
Radon	A radioactive gas that is released by uranium, a natural substance found in soil and rock. Radon is captured in indoor air by moving through the ground to the air above.	Impacts: • Damage to lung cells • Leads to lung cancer
Environmental tobacco smoke (ETS)	Mixture of smoke from the burning end of a cigarette, pipe, or cigar and smoke exhaled by the smoker (also second hand smoke or passive smoking).	ETS is particularly harmful to infants and children and effects include: • Asthma • Sudden Infant Death Syndrome • Bronchitis and pneumonia • Other respiratory diseases Passive smoking may also lead to: • Lung cancer • Eye, nose and throat irritation • Potential effects to the cardiovascular system
Cooking pollutants	Cooking with solid fuels on open fires or traditional stoves.	Impacts on children: • Respiratory illnesses including pneumonia Impacts on adults: • Respiratory diseases and infections • Increased susceptibility to asthma • Changes in lung function
Volatile organic compounds (VOCs)	Compounds that vaporize (become a gas) at room temperature. Common sources which may emit VOCs into indoor air include housekeeping and maintenance products, and building and furnishing materials.	Some VOCs are known carcinogens and other harmful effects to health include: • Eye, nose, and throat irritations • Headaches • Dizziness • Visual disorders • Memory impairment

Passivhaus: Residential Construction Project

This new residential construction project in Indiana, featuring strand bamboo flooring, was built and certified to the Passivhaus standard. Passivhaus is an extremely rigorous building standard focused primarily on developing an airtight building envelope, and only recently started to take off in North America, around 2008. Essentially, the goal of a Passivhaus is to eliminate the need for interior heating and cooling, but still maintain a comfortable and healthy indoor environment at all times through strategic and site-specific layout and design.

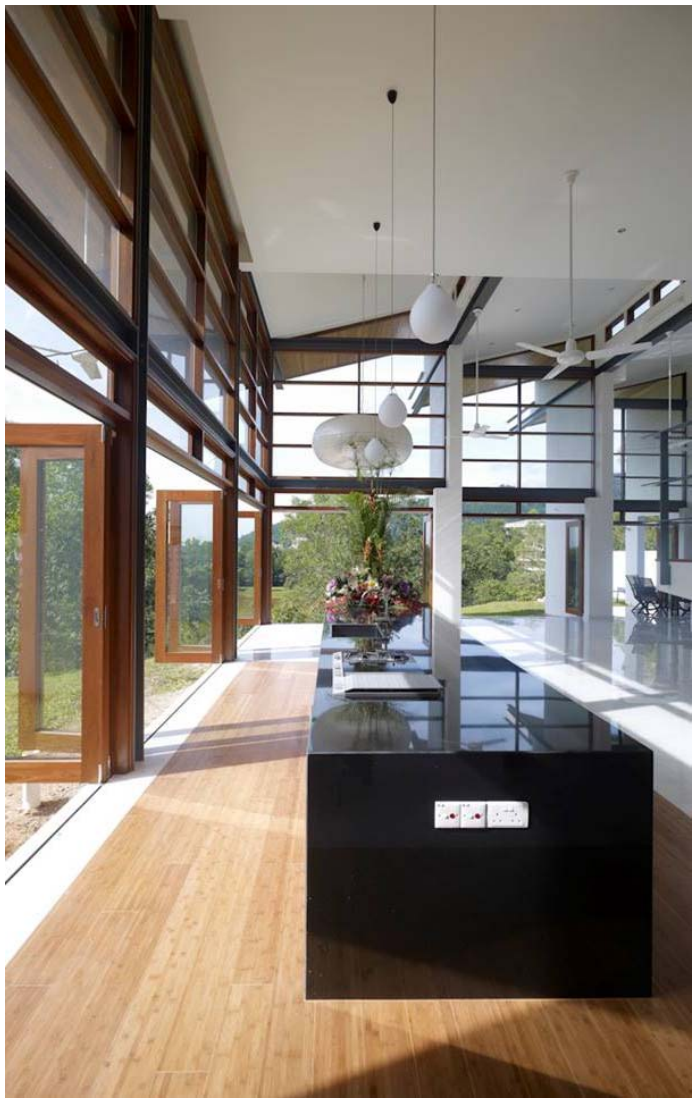
Due to the incredible air-tightness of a Passivhaus building envelope, it is absolutely essential that air quality inside the home be healthy from the start. Every construction material, furnishing, and cleaning product is rigorously scrutinized to ensure that it will not release VOCs. Bamboo flooring with a FloorScore certification was chosen for its ability to meet these high standards.

Views of Nature: Benefits

In today's modern world, we spend on average 90% of our lives inside buildings. This staggering statistic only reinforces how important it is to ensure that buildings are designed and furnished to promote the health and well-being of their occupants.

Myriad psychological studies have proven that views of nature and greenspace, from both residential and workplace environments, can contribute significantly to improved mental health and well-being. Specific documented benefits include the following:

- Improved focus and organization
- Increased emotional resilience
- Faster recovery from illness
- Decreased mortality among the elderly
- Reduced stress and anxiety, and lower blood pressure



Positive Health Impacts of Natural Wood Interiors

Recently, researchers at the University of Tampere in Finland have determined that the presence of natural wood in interior environments has positive health impacts similar to views of nature. These findings have been reinforced by studies conducted in Norway, Japan, Canada, and Austria.

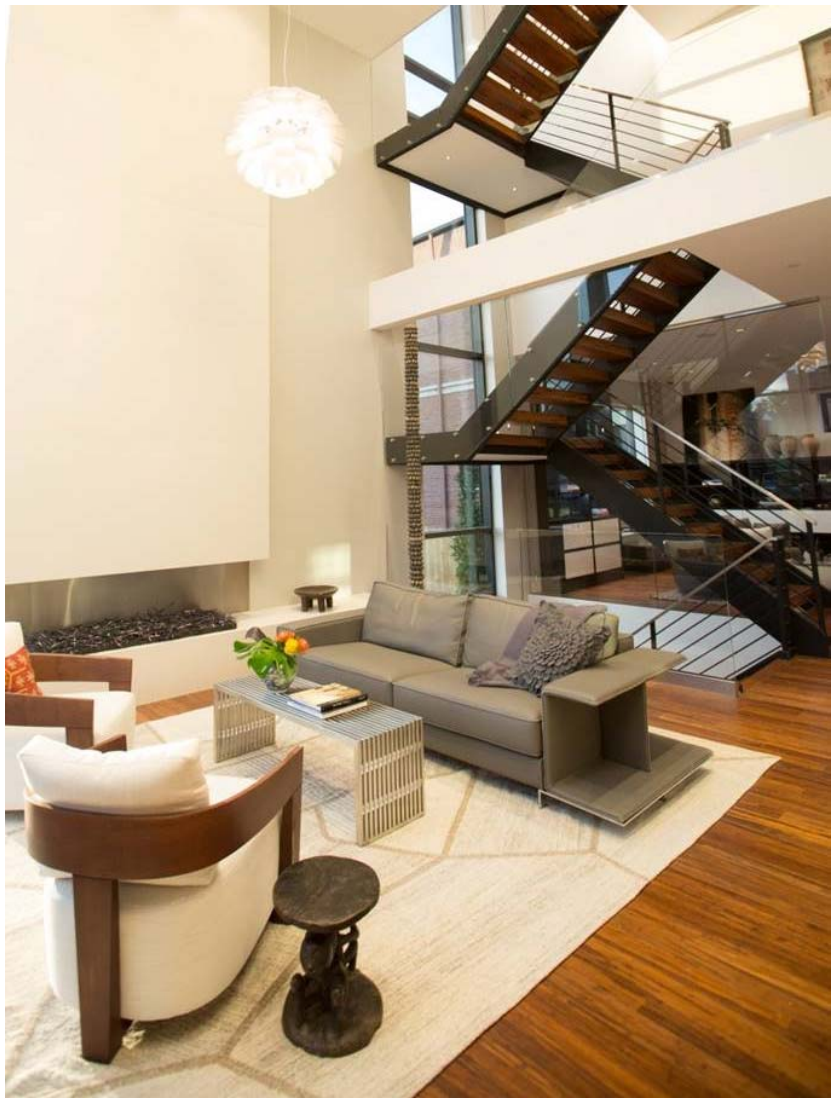
The benefits of natural wood interiors include decreased blood pressure and pulse, lower levels of stress in occupants, and increased emotional well-being. These effects were particularly striking in a classroom study done among school-aged children where the normal morning stress peak (as measured by increase in pulse rate) observed in traditional classrooms was completely absent in a classroom with an all-wood interior.

In another study, it was found that touching wood products produces a physiological safety response—building occupants feel safer and more at ease when in physical contact with natural wood products. In contrast, touching room temperature aluminum, plastic, or stainless steel causes a rise in blood pressure.

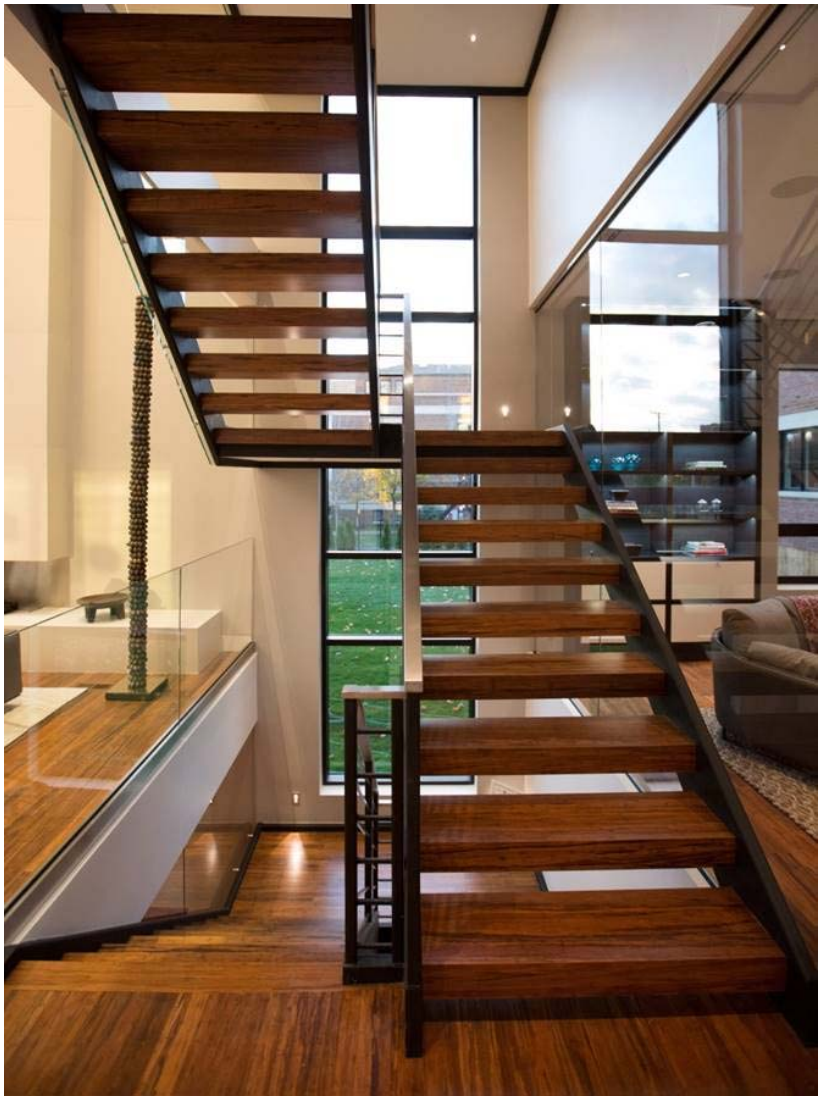
Side-by-side studies have shown that these positive health impacts cannot be replicated with the use of imitation wood.

2012 Chicago Healthy Home

The 2012 Chicago Healthy Home (pictured here) was designed and built for a young family with severe chemical sensitivities. Sponsored by the non-profit Healthy Child Healthy World, the goal of the project was to use non-toxic construction materials and components from foundation to finish. Strand bamboo flooring was used throughout.



2012 Chicago Healthy Home



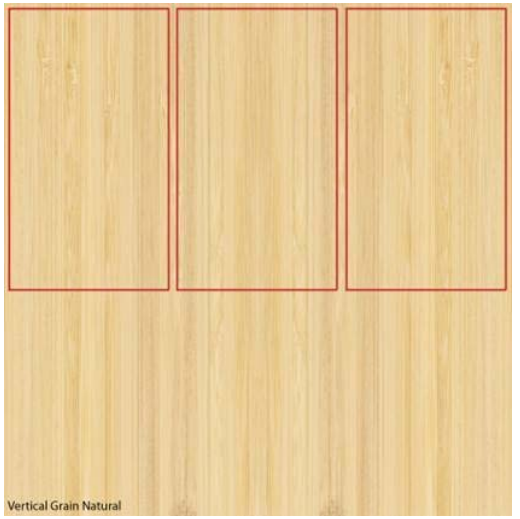
Working with Bamboo as a Material

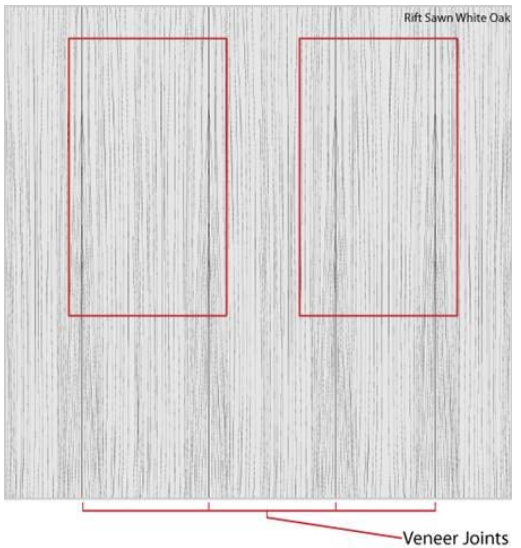
Workability: Bamboo vs. Hardwood

Because traditionally-styled bamboo is simply a series of laminated slats, and strand bamboo is made in either sheets or blocks, a variety of different products can be milled from these base materials, including classic panels and veneer.

Bamboo panels, as we know them today, were first manufactured in the 1940s. These products have remained popular with woodworkers over the years for a variety of reasons.

One reason is the increase in yield of usable material per square foot that is possible with bamboo compared to common hardwood panel products, due to the absence of veneer joints. When positioning a cut-out from a hardwood panel, woodworkers must accommodate veneer joints to ensure that they are positioned symmetrically on the end product; this is not a concern with bamboo, resulting in significant savings.





Hospitality Installation: Washington, D.C.

This commercial hospitality installation at Nusta Spa in Washington, D.C. used vertical grain traditional bamboo panels with a dark stain applied. The designers were able to achieve the look and quality they were after, while also keeping costs down due to the increased yield per panel made possible with bamboo.

No Edge Banding

Another financial benefit of bamboo paneling is that it does not require edge banding. In fact, the “piano key” appearance along cut edges of bamboo panel material is a natural result of its cross-ply construction; it is often highlighted as a design feature and one of the reasons for choosing bamboo over other materials.

Installation: Best Practice Resources

From a workability standpoint, bamboo can be treated just like any other hardwood product. Construction methods, adhesives, and application of finishes all comply with standard woodworking methods.

The Architectural Woodwork Institute (AWI) Quality Standards are a good best practice guide to use to get started if you are unfamiliar with common woodworking techniques for panels and veneer. Over 1,000 AWI-certified fabricators are capable and qualified to work with bamboo materials.

On the flooring side, National Wood Flooring Association (NWFA) standards and best practices also apply. There are NWFA-certified flooring installers throughout North America.

Custom Acoustic Ceiling Installation
Using Traditional Bamboo Panels

Variety of Finishes

A variety of finishes can be used with bamboo, including oils, waxes, and stains. Bamboo is often chosen for its positive environmental qualities and its indoor air benefits, so if you are selecting bamboo for these reasons, it is important to make sure that you are also selecting a finish option that meets these requirements.

While bamboo flooring often comes prefinished, for panel and veneer products being used to create cabinetry, furniture, or other surface treatments, finishes will need to be applied at the time of fabrication.

Shown here are traditional bamboo panels in a variety of colors, achieved using an eco-friendly, water-based dye.

Precision Milling

Well manufactured bamboo products machine very cleanly, as is demonstrated in this multi-unit residential lobby installation in Honduras. The back wall feature includes a large graphic application over which bamboo panels have been finely milled into slats, revealing the image behind. The bamboo paneling had to meet high-quality standards for precision milling in order to achieve the clean lines and edges that make this a successful installation.

Bamboo Veneers

Bamboo veneers can be applied to various substrates in order to achieve specific design goals. In this installation for a company's dining hall, bamboo veneer was overlaid on a flexible substrate to achieve the curve seen in the suspended ceiling panels.

Core and substrate materials come with a variety of attributes. Some include the following:

- Flexible for radius applications
- Fire rated
- No added formaldehyde for better indoor air quality
- Lightweight

Just like with finishes, when specifying a bamboo veneer over a core, make sure that the core material also qualifies for needed environmental or air quality ratings.

Bamboo Doors

In addition to basic surface applications of bamboo as flooring and wall treatments, many other products can be specified that are made from bamboo.

Often bamboo is chosen as a material by original equipment manufacturers (OEMs) due to its available LEED credits and environmental certifications, which in many cases, dovetail with sustainable efforts already being made by the manufacturer. For example, in the doors shown here from Greenleaf, water-based glues and a recycled content medium-density fiberboard core are already in use. By using bamboo veneer as well, these doors qualify for the maximum possible LEED credits.

Bamboo Ceiling Fans & Snowboards

This ceiling fan by Big Ass Solutions uses three-dimensional heat-molded bamboo veneers to make its patented blade design. In this instance, bamboo was chosen for its indoor air quality certification and its FSC certification.

The bamboo snowboard features an original art design that has been screen printed onto the material. The entire piece has then been finished with a water-proof coating.

Bamboo Furniture

The selection of either traditional or strand bamboo panels and veneer can create versatile furniture designs that range from classic to contemporary.

Bamboo Bedroom Set and Office Furniture by Greenington

Unlimited Design Potential

As with any natural material, when it comes to possible applications for bamboo in design, your imagination is the limit.

Bamboo Light Fixture by Propellor

Curved Bamboo Inlay in Mosaic Tile Wall – Commercial, Retail

Commercial – Restaurant: Israel

Custom Bamboo Wall Treatment

Custom Bamboo Screens Milled from Solid 3-Ply Bamboo Panels

Market Insight: Residential Applications

2013 Houzz & Home Survey

The 2013 “Houzz & Home Survey” conducted by Houzz, an online ideabook and social networking site for design professionals and their customers, was the largest survey of homeowner renovation and decorating activity ever conducted. With over 100,000 respondents, this survey was able to hone in on not only how homeowners are spending their remodeling and decorating dollars, but also why.

The results show homeowners who are engaged in the design process and know what they want.

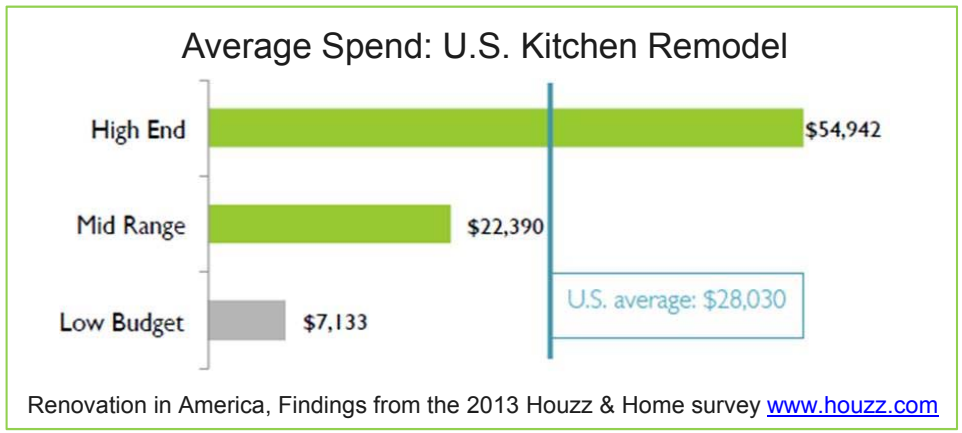
Traditionally-Styled Bamboo Floor with Grey Stain, Residential Kitchen, Washington State

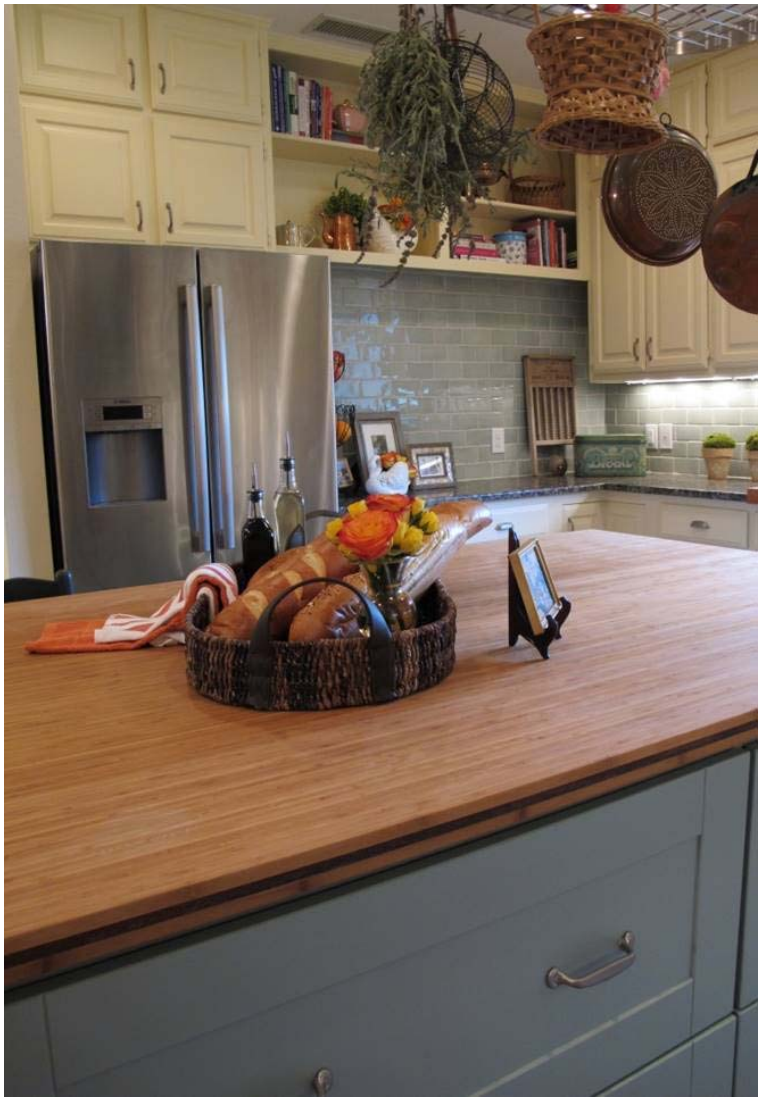
2013 Houzz & Home Survey

48% of homeowners nationwide plan to remodel, build an addition to their home, or build a custom home over the next two years.

As expected, the highest budget rooms are kitchens and baths, with 40% of remodeling dollars going to the kitchen alone.

23% of homeowners are planning a kitchen remodel in the next two years.





Bamboo Counter on Kitchen Island, 2012 Residential Remodel, Texas

2013 Houzz & Home Survey

28% of homeowners are planning a bathroom remodel or addition in the next two years.

58% of homeowners across all remodeling projects intend to hire professional help.

Most homeowners are remodeling for themselves, to enhance the enjoyment of their space, and plan to stay in their homes for the next 5–10 years. For this group, high-quality bamboo materials that are durable and will last provide added value.

Bamboo is often used in both kitchens and bathrooms in order to bring a natural material into spaces that so frequently have metal and stone components. Bamboo lends a sense of warmth and texture to these environments.

Residential Bathroom Application

The slight inward tilt on the design and wall-mounted application provides more visual floor area, creating a greater overall sense of space.

Custom Double Vanity Made with Traditionally-Styled Bamboo Panels – Vertical Grain Natural

Residential Kitchen Application

Custom cabinets for this modern kitchen were done using traditionally-styled bamboo panels with a very dark stain applied.

Residential Kitchen Application

Here is an example of hinged kitchen cabinets in a contemporary design, using traditionally-styled bamboo panels.

Residential Kitchen Application: Traditional Design

When most people think of bamboo cabinets, they think of the previous designs—something fairly contemporary. However, strand bamboo, with its hardwood look-alike grain, can accommodate versatile designs, even the very traditional.

The classic Shaker style cabinets shown here are done in a chestnut strand bamboo.

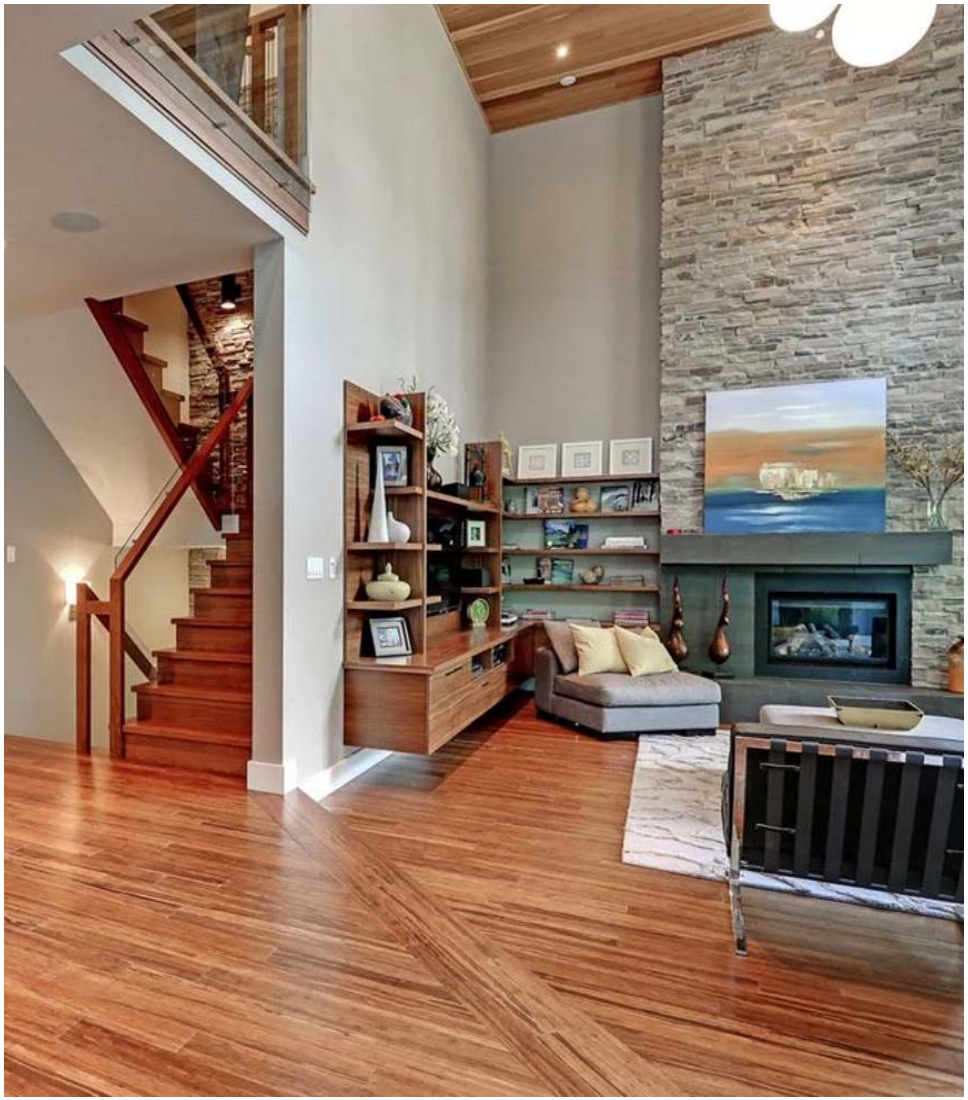
Residential Applications

A 2013 independent survey by a leading U.S.-based bamboo manufacturer found that kitchens were the third most popular place in the home for customers to install bamboo.

The first and second respectively were family/living rooms and bedrooms. In these spaces where built-in cabinetry was less common, the emphasis was on bamboo flooring.

Top reasons given by homeowners for choosing bamboo were:

- Style
- Eco-Friendliness
- Durability



Summary

Attributes of Bamboo

Bamboo is…

- Beautiful
- Durable
- Renewable

Please remember the **exam password STRAND**. You will be required to enter it in order to proceed with the online examination.

Why Choose Bamboo?

Design:

- Traditional – Zen look
- Strand – hardwood look-alike

Compared to Hardwoods:

- Increased hardness and durability
- “Locks up” more carbon
- Rapidly renewable resource

Health Benefits:

- Improved indoor air quality
- Benefits of a natural material

Workability:

- Just like hardwoods

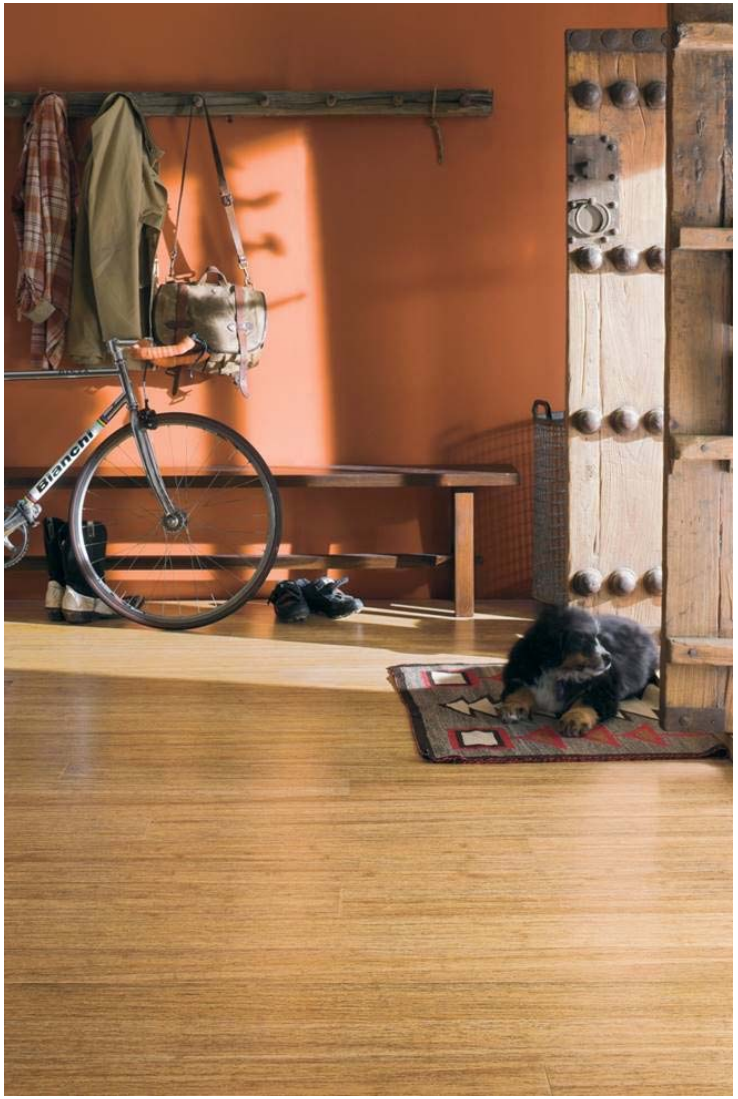
Available Credits & Certifications

Human Health Impacts – Indoor Air Quality

- CA01350 : FloorScore and GREENGUARD use this standard for their certifications as well
- LEED Credit IEQ 4.3

Environmental Impacts

- Forest Stewardship Council
- LEED Credit for Certified Wood
- USDA BioPreferred
- LEED Credit for Rapidly Renewable Resource



How to Specify

When specifying bamboo products, make sure to call-out the following:

Material
- Species: Optimum 5.5 Moso Bamboo
- Hot press style strand bamboo (optional)
- ASTM D 4442 delivered moisture content of 7–10%, oven dry method

Performance
- ASTM D 1037 Janka Hardness Rating at or greater than 1500 for traditional bamboo/3250 for strand bamboo
- ASTM D 3501 compressive strength minimum 14,080 psi (96 Mpa)
- ASTM D 1037 dimensional change coefficient 0.00086 (for strand) or 0.00163 (for traditional)

Certifications
- CA01350 certified for indoor air quality
- FSC COC certified (optional)
- USDA BioPreferred certified (optional)

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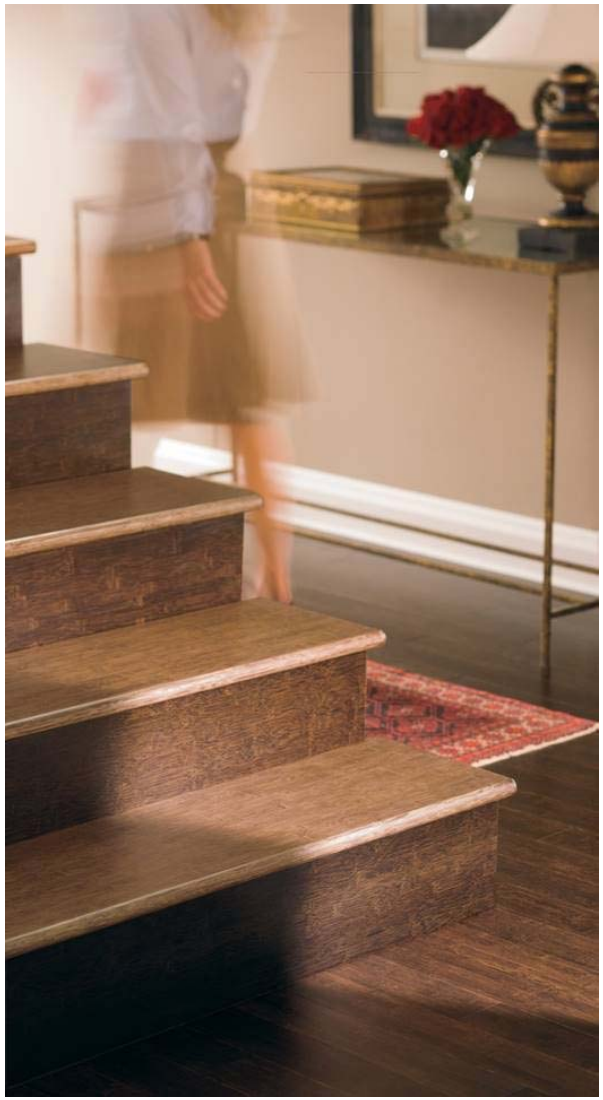

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