

Wood and Indoor Environment

Creating beneficial spaces for living, working, well-being

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The objectives of sustainable design are broader than just environmental effects, having come to embrace issues of human health and performance. As sedentary and service-related work becomes more prevalent in our society, the amount of time people spend inside buildings increases—the average North American spends 90 percent of his or her time indoors, another 5 percent in cars and only 5 percent outside. This not only makes the design of building interiors ever more important, but calls for the buildings themselves to provide a connection to nature that will only get harder to come by.

Many factors influence whether a building has a positive or negative impact on its occupants. This course highlights remarkable

Photo by Richard Mandelkorn

**Bolton Dining Commons,
University of Georgia
Athens, Georgia
Smith Dalia Architects,
Bruner/Cott & Associates**

In this 50,000-square-foot dining commons, Douglas-fir structural roof decking and truss timbers respond to the client's desire for natural materials that evoke feelings of warmth and comfort, have visually appealing textures and patterns, and resonate with students and staff.



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Learning Objectives

After reading this article, you should be able to:

1. Define the relationship between a building's sustainability and the health and performance of the building's occupants.
2. Explore how wood was used to enhance the experience of building occupants in projects from around the country.
3. Recognize how wood used as a structural and finish material contributes to key elements of occupant environment including indoor air quality, acoustic performance, and physical health.
4. Examine evidence confirming the positive human response to wood for its aesthetic qualities and connection to nature.

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buildings where the use of wood as a structural or finish material has made a unique contribution, with a focus on indoor air quality, acoustics, physical health, and a natural, positive human response to wood that has always been intuitive, but is increasingly being proven by research and experience.

“This is one of the most overlooked aspects of sustainability. It’s not about the points. It’s about designing places where people want to be,” says Marc L’Italien of EHDD, discussing the LEED Platinum-certified David and Lucile Packard Foundation Headquarters, one of the innovative projects featured in this course (see page 7). Wood has been extensively researched and shown to be sustainable by measures that include renewability, embodied energy, air and water pollution, and carbon footprint. But it also performs well in areas that are essential to occupant comfort and performance, resulting in spaces where people feel good and do well over long periods of time.

Architect Reese Rowland, a principal at Polk Stanley Wilcox whose projects include the Hillary Rodham Clinton Children’s Library (see sidebar on page 4) agrees. “Our most recognized spaces are those where wood is prominent,” he said. “Whether the story calls for a progressive, modern language or something more transitional, the key to the most memorable spaces is warmth and natural light. Wood gives warmth like no other material.”

INDOOR AIR QUALITY

Indoor air quality is a basic requirement for humans in any space. Wood itself is considered to be hypoallergenic; its smooth surfaces are easy to clean and prevent the buildup of particles that are common in soft finishes like carpet. Solid wood products, particularly flooring, are often specified in environments where the occupants are known to have allergies to dust or other particulates.

Most wood structural panel and engineered wood products use phenolic resins or diphenylmethane diisocyanate (MDI). Their unique chemistry makes these waterproof adhesives highly durable and stable, resulting in negligible formaldehyde emissions. Large-scale chamber tests have shown that formaldehyde emission levels in wood structural panels are no higher than the levels found naturally in the environment. For this reason, formaldehyde levels associated with phenolic resin-bonded products are exempt from the U.S. Department of Housing and Urban Development (HUD) testing and certification requirements.

The use of wood products can also improve indoor air quality by moderating humidity. Acting like a sponge, the wood absorbs or releases moisture in order to maintain equilibrium with the adjacent air. This has the

Photo by Benjamin Benschneider, courtesy of Mahlum Architects



One of the many innovative uses of wood on the exterior and interior of new student housing at the University of Washington in Seattle.

effect of raising humidity when the air is dry, and lowering it when the air is moist—the humidity equivalent of the thermal flywheel effect.

SOUND OF WOOD

Architect Marcy Wong, whose firm Marcy Wong Donn Logan Architects frequently uses wood for its acoustic properties, articulates the connection between acoustics and sustainability in this way: “In addition to the usual sustainable advantages of wood—renewability, nontoxic, carbon storing—there is an additional aspect, that being acoustics. Sustainability is more than being responsible about the impact of a project on the earth’s resources and climate, but also on the quality of environment for users.”

Photo by Nic Lehoux, courtesy of Bing Thom Architects



Arena Stage at the Mead Center for American Theater Washington, D.C. Bing Thom Architects

For centuries, wood has been the material of choice for architects and designers intent on delivering the highest quality acoustic performance. From a violin to a concert hall, wood plays a role in delivering memorable acoustic experiences. Wood produces sound by direct striking and it amplifies or absorbs sound waves that originate from other bodies. For these reasons, wood is an ideal material for musical instruments and other acoustic applications, including architectural ones.

Wood is not as “acoustically lively” (translation: noisy) as other surfaces. Post-occupancy evaluations of buildings have revealed that poor acoustic performance is a common problem in buildings with large areas of hard, acoustically reflective surfaces. Ironically, such surfaces are frequently found in buildings designed to be sustainable, where the use of absorbent materials is minimized due to indoor air quality concerns.

In large buildings with hundreds or even thousands of occupants—for example, apartment buildings, condominiums, hotels or dormitories—every acoustic detail has a positive or negative effect on the quality of daily life. Wood-frame construction is efficient in buildings where sound insulation is required. In particular, wood doesn’t present the impact noise transmission issues commonly associated with other types of construction.

University of Washington

In 2012, the University of Washington in Seattle added nearly 1,700 student housing beds by constructing three residential halls and two apartment buildings, all of which include five stories of wood-frame construction over two stories of concrete. Designed by Mahlum Architects and winner of a WoodWorks Wood Design Award, the 668,800-square-foot project

Photo by Peter Vanderwarker



Peoples Health New Orleans Jazz Market
New Orleans, Louisiana
Kronberg Wall Architects

is the first of four phases planned to add much-needed student housing to the urban campus.

“Acoustics are important for any multifamily housing project, but especially for student housing,” says Anne Schopf, FAIA, a design partner with Mahlum. “Mitigation measures must be weighed against budget, which is why we brought in experts from Seattle-based SSA Acoustics for the design of this project.”

Because they knew single stud walls would not provide adequate performance, SSA recommended staggered stud walls between residential units. Since there is no rigid connection between the gypsum board on each side (except at the plate), a staggered stud wall performs better than a single stud wall. Double stud walls perform better than a staggered stud design because plates are separated by an air space, so they used double stud walls between residential units and common spaces (e.g., lounges, staircases, and elevators) and service areas.

In the floor/ceiling assembly, they paid careful attention to the installation of resilient channels, which are often one of the main causes of failed floor/ceiling assemblies from an acoustical standpoint. In fact, SSA says there’s a difference of 8 to 10 IIC and STC points between assemblies with resilient channels versus those without. Channel installation has fairly straightforward requirements; for example, screws for the gypsum board should never touch the framing behind the resilient channel.

“We used enhanced acoustical walls between rooms in the same unit,” says Mohamed Ait Allaoua, a managing partner at SSA. “Although

not a typical approach in multifamily buildings, this is important in student housing projects where people within a relatively small space have different needs—if one student wants to watch TV in the living room, for example, while another is studying in the bedroom.”

Peoples Health New Orleans Jazz Market

For Atlanta-based Kronberg Wall Architects, one of the greatest challenges in designing this 14,000-square-foot contemporary jazz performance space, was acoustics. Located in an historic building in the birthplace of jazz—and home to the New Orleans Jazz Orchestra—the acoustics needed to add vibrancy and energy to the music being performed. According to firm principal Eric Kronberg, part of the design brief was also that the aesthetics of the space should “feel as warm as Louis Armstrong’s horn sounds.”

Working with acoustics consultants Kirkegaard Associates, Kronberg Wall used wood for a majority of the reflective surfaces both to create the desired sound and warm aesthetic.

The team designed a carefully shaped pair of acoustic ‘clouds’ over the stage combined with curved, wood-clad cheek walls that extend out into the hall. These surfaces are designed to reflect sound back to the musicians for on-stage communication and out to the audience for a more exciting experience.

The hall includes salvaged cypress planks, oiled instead of polyurethaned to maintain a slightly porous surface. “The oil finish allowed

Photo by Casey Dunn, courtesy of Dunnam Tita Architecture + Interiors



Research is confirming that interiors with natural materials and views, exemplified here in the Greater Texas Foundation in Bryan, Texas, can lower stress and promote relaxation.

the highest pitch sounds to be slightly absorbed by the wood,” said Kronberg. “This helped to avoid excessive brightness and made the overall sound warmer.” All of the wood was installed tongue and groove with hidden fasteners so it performs acoustically as a solid surface.

Arena Stage at the Mead Center for American Theater

When Arena Stage at the Mead Center for American Theater reopened after a major renovation, it was the first modern structure of its size to use heavy timber components in the United States capital. It was also the first project in the U.S. to use a hybrid wood and glass enclosure to envelop two existing structures, both historic theaters from the original site.

Designed by Bing Thom Architects and winner of a WoodWorks Wood Design Award, the result is an ambitious space where the visitor experience is deeply affected by the innovative use of wood—where 18 parallel strand lumber columns, each 45 to 63 feet tall, brace a tall glass façade against wind loads and carry roof loads (up to 400,000 pounds) from the steel roof trusses, some as long as 170 feet.

However, while much has been written on the columns, wood was also chosen for its acoustic capabilities. A third theater, a smaller space referred to as the Cradle, posed a challenge due to the sound reflections caused by its oval shape. So the project team developed a wall system that would appear visually substantive, but could absorb and disperse sound so the actors’ voices carry properly in the space. “After some trial and error, we developed a wood slat

CREATING A 'SENSE OF PLACE' IN PUBLIC BUILDINGS POLK STANLEY WILCOX ARCHITECTS

In the introduction to this paper, Arkansas-based architect Reese Rowland, FAIA, of Polk Stanley Wilcox, is quoted as saying wood gives warmth to a building like no other material. reThink Wood was speaking to Reese about the civic projects in his firm's portfolio, and the fact that several include wood roofs that add significantly to the experience of being in those buildings. "A sense of place is what makes a great building, community, and city," he said. "For our firm, the quest for meaning in each project has led to the creation of very personal architectural expressions that are unique to each client's place, time and story. Wood has always been a natural choice to tell those stories."

For the 30,000-square-foot Hillary Rodham Clinton Children's Library, a charrette with local children revealed that their main desire wasn't for the latest video games, but a forward thinking space that 'lifted expectations' and was warm and inviting. The team chose a modern expression of the "Hundred Acre Wood" childhood memories of many Arkansans, and Rowland says wood was the only material that could provide the necessary warmth, color and textures. Completed in 2013, the project includes a tongue and groove Southern pine roof deck made from local lumber, as well as a wood slat system designed to replicate the walls of barns and filter clerestory light from the butterfly roof above.

At the El Dorado Conference Center, wood was used as a main expression to exude a timeless quality, referencing a history of timber and oil that helped the city flourish while contributing to its growing role as a regional conference destination. The architecture references the region's history without simply repeating an historic style, and allows a seamless blending of public, business and educational uses. Roofs over the public halls include glue-laminated (glulam) timber beams with structural tongue and groove decking on wood purlins, and are cantilevered to the west for sun control.

Highlighting the thread of 'honest structural expression' throughout these projects, the main anchor of the Heifer International Murphy Keller Education Center is a 2-foot-thick curved concrete wall, representing the barrier between industrialized nations and the world where the majority of humans live. Floating lightly from the wall, a timber roof, supported by glulam beams, is freed and separated by a continuous skylight, reflecting light onto the wall and exhibits. Maple-slatted walls hide air grilles, provide a means to hang exhibits and reduce sound reverberation. The exhibit space extends to a giant wood porch, where tree columns branch out, gently touching the pine roof canopy, extending the forest into the building form.



Heifer International Murphy Keller
Education Center
Little Rock, Arkansas



Hillary Rodham Clinton Children's Library
Little Rock, Arkansas



El Dorado Conference Center
El Dorado, Arkansas

Photo by Peter Sellar, Tye Farrow of Farrow Partnership,
courtesy of naturallywood.com



Credit Valley Hospital in Mississauga, Ontario,
is one of an increasing number of healthcare
facilities making use of exposed wood to
create a warm, natural aesthetic that supports
their healing objectives.

system made from poplar, designed to look like a basket weave," said Michael Heeney, principal and executive director at Bing Thom Architects. "The unique wall, which was cost-effectively installed by our drywall contractor, gave us the character and acoustic dispersion we needed."

The team also used stained poplar to warm and absorb sound in the lobby, which is big enough for 1,400 patrons from all three theaters to gather at the same time.

HEALTH IN NATURE

The definition of sustainable building continues to deepen as we understand more about the impact of buildings on the environment and on people. One of the most promising areas of focus is "evidence-based design," which involves using information gained from the rigorous analysis of past buildings to build better new ones. Healthcare architects have been at the forefront of this effort, exploring the physiological benefits of good design on patient recovery and the well-being of staff and visitors. Among the results, an increasing number of healthcare facilities are making use of natural daylight, views of nature, and exposed wood to create a warm, natural aesthetic that supports their healing objectives. These same techniques are also being used in schools and offices to improve performance, productivity, and occupant well-being.

Humans have a natural affinity for nature. Being in a natural environment—a forest, park or garden—can make us feel more relaxed. The term "biophilia" has been coined to refer to this phenomenon. Although most

of us understand the connection intuitively, the stress-reducing effects of outdoor nature are also well documented from a scientific perspective. Exposure to nature has been shown to lower blood pressure, heart rate, and aggression. Nature also increases the ability to focus attention and perform concentration and creative tasks. One landmark study of hospital patients recovering from abdominal surgery found that patients in rooms with a view to nature had shorter post-operative hospital stays and required fewer analgesics than patients with a view of another building from their window.¹

But what about the “average North American” spending 90 percent of the time indoors? In addition to views of nature itself, there is growing evidence that a positive relationship exists between humans and natural materials.

For example, a 2012 study at the University of British Columbia and FPInnovations demonstrated that the presence of visual wood surfaces in a room lowered sympathetic nervous system (SNS) activation. The SNS is responsible for physiological stress responses in humans.

In the study, four office environments were created to examine the effects of natural materials on autonomic nervous system responses. The rooms were identical except for either wood finishes (birch veneer) or white finishes, and the placement of either plants or non-natural objects. Stress as measured by SNS activation was lower in the wood room in all periods of the study. Temporary spikes in skin conductivity (associated with stressful thoughts or stimuli) were also measured. Once again, the subjects in the wood room had statistically fewer of these responses, interpreted as fewer stressful thoughts.

Building on this study, the 2015 report, *Wood as a Restorative Material in Healthcare Environments*,² reviews available research on the human response to natural elements in the built environment, concluding that it is reasonable and desirable to employ more wood in healthcare environments.

The report states: “In the small but growing volume of research on wood and health, the results that are emerging mirror results we have seen from exposure to other natural elements, such as views and plants. Lower stress reactivity in the autonomic nervous system is found when wood, plant, or nature views are present. Lower sympathetic activation and higher parasympathetic activation result in measurably lower heart rate, lower blood pressure, lower skin conductivity, and higher heart rate variability. These results have been linked to exposure to wood. However, lower stress activation due to views and plants have also been shown to increase the ability to concentrate, lower pain perception, and speed

Photos by Jeremy Bittermann, courtesy of EHDD



Occupants of the David & Lucile Packard Foundation headquarters are in constant contact with nature, indoors and out. Wood is the main exterior cladding material of the LEED Platinum building (top), and features prominently in the interiors (bottom), with extensive views of the outdoor courtyard.

recovery times. Though these benefits have not been identified for wood, they are tied to the same automatic responses to nature seen with wood. Therefore, it is reasonable to expect that future research on wood will find many of these same results.”

The report goes on to say that, “In healthcare environments, natural materials and views are associated with better patient outcomes with respect to recovery times, lower pain perception, and positive dispositions. This alone is reason for including more wood in these buildings. However, healthcare facilities are populated not only by patients, but also their visiting families and the practitioners that treat them. These people also benefit from the pro-health effects of nature. [...] Further, the link between natural elements and the ability to focus attention cannot be ignored for healthcare practitioners who work all hours and often do not have access to the benefits of natural light.”

HUMANS LOVE WOOD

Although not the most scientific of statements, the reaction of people to the projects featured in this course can only lead to the conclusion that “humans love wood.” Acoustic performance can be carefully measured and calibrated, and so can blood pressure and skin conductance. But the deep positive connection between humans and wood materials is just as powerful, though harder to measure. Reasons given by clients and architects for choosing wood often include references to beauty and warmth, connection to both the local landscape and larger nature, “upscale” connotations, and the expression of an organization’s core values and mission.



For example, there are many reasons why a school district might opt for wood construction—including lower cost, speed of construction, sustainability, and the flexibility to address changing needs. Schools get a lot of abuse, so durability is also important. And good acoustics, as discussed, are an essential condition for student learning.

But as we have seen, there is a deeper, if less measurable, reason why wood is chosen as a central design element for many schools. Architects, not to mention students, teachers, and parents, often believe that exposed wood enhances learning by providing an inviting and enriching environment—a belief that is not unique to North America.

In Japan, for example, officials at the Ministry of Education believe wood has numerous qualities that promote the learning process. In a three-year study of 700 schools, Japanese researchers studied how the educational environment is shaped by the type of materials used for school buildings. Data found reduced flu outbreaks in wood-framed schools compared to concrete facilities.³ A

RECLAIMED WOOD

In contrast to other materials, wood can typically be reclaimed and reused at the end of its service life, with only minor modifications and little waste. Reclaimed wood can be reused for its original purpose, for example as structural members, or remilled and fashioned into other products such as window and door frames, curtain wall components and cladding. Or it can be used for innovative new purposes, where it can bring not only enhanced sustainability, but a meaningful legacy for the people who use the new building.

In an early project coordination meeting with the City of Bryan, Texas, the project team was asked if they were planning to use wood as a significant feature in the planned new Greater Texas Foundation building. They were, and the city informed them of a warehouse building slated for demolition very near the site. Through a novel collaboration between the client and the city, the team—led by Dunnam Tita Architecture + Interiors—was able to salvage a large quantity of antique long-leaf pine from the structure of the demolished building. This “very local” reclaimed material is now prominently featured throughout the new building, in applications that range from structural blocking inside walls to finished wood floors, exposed roof decking, wood ceilings, the front door, and several custom furniture pieces.

The reclaimed wood helped meet high sustainability goals. “We were able to reduce the use of new materials by reusing others,” explains Wendy Dunnam Tita. “In so doing, we even avoid the embodied energy associated with the recycling process where one material is turned into an entirely different one.”

Photo by Casey Dunn, courtesy of Dunnam Tita Architecture + Interiors



Greater Texas Foundation, Bryan, Texas

The reclaimed wood was a favorite aspect of the building for almost everyone involved. “The client and team love how it looks, functions, sounds and feels as well as the wonderful story of how one building was carefully taken apart to build another one.”

The Freight & Salvage Coffeehouse, designed by Marcy Wong Donn Logan Architects, exemplifies the use of wood where acoustics, reclaiming history, and expressing ideals all come together.

As a non-profit community arts organization with roots in the heady Berkeley counterculture of the 1960s, the Freight & Salvage had three major objectives for the design of its new theater: first, to maintain the comfortable, folksy ambience that had made it famous; second, to uphold standards of environmental consciousness and stewardship befitting the organization’s emphasis on progressive social action; and third, to obtain a world-class and modernized theater space within a tight budget raised entirely through donations. Luckily the use of wood throughout the project—especially wood salvaged from the existing building on site—contributed to all of these objectives.

Much of the new building’s structural system (in the form of salvaged wood trusses) and all of the paneling in the theater (re-milled from the existing roof decking) came from the site’s previous building. The weathered wood used in the theater auditorium—combined with state-of-the-art acoustic backing—created a striking, vintage feel that would have been difficult to recreate with another material.

According to the Freight & Salvage’s artistic director, “The theater is not only technically and acoustically beyond reproach and visually beautiful. As it perfectly represents our organization’s unique mission, it is truly inimitable.”

Photo by Sharon Risedorph Photography, courtesy of Marcy Wong Donn Logan Architects, Inc.



Freight & Salvage Coffeehouse, Berkeley, California

second Japanese study surveyed teachers and students to measure their impression of wood versus reinforced concrete—and both groups had similar, favorable impressions of wood schools. Results also showed that teachers and students in wood buildings felt less fatigue, and that students perceived schools with larger areas of wooden interiors to be brighter than reinforced concrete structures.⁴

Another study, this time in Austria, found that interior wood use in classrooms reduced pupils’ stress levels, as indicated by criteria that

included heart rate and perceived stress from interaction with teachers.⁵

Vashon Island High School

Closer to home, the new Vashon Island High School (VHS) in Washington State reflects the island community’s values and desires to promote thoughtful stewardship of natural resources. Community members helped define goals for the project, including minimizing carbon footprint, ensuring protection of two adjoining watersheds, and reducing both

embodied energy and energy consumed during the building’s operation. Designed by Integrus Architects, the building itself serves as a living textbook by integrating sustainable lessons and mindset into daily school life, helping to teach students to care for the environment they’re inheriting.

The project goals presented the design team with a complex challenge: to create a modern school facility in alignment with current high-performance educational programs that also serves as a vital hub for the community, and

to respond in a meaningful way to the island's unique culture, traditions, and commitment to sustainability. The unique building form and the place-based material palette sought to bring these elements together. The incorporation of wood throughout and extensive daylighting were key to the strong indoor-outdoor connection desired by the community. Large roof overhangs provide extensive outdoor shelter in inclement weather. Shed roofs and clapboard siding give a nod to the Island's agrarian vernacular, while the exposed wood structure and expansive glazing ground the building in a modernist tradition appropriate for its place and time. The building is painted a deeply saturated red, providing an appropriate image of the little red schoolhouse in a close knit community, and complementing the deep green hues of the surrounding forest.

Forested land adjacent to the high school and owned by the school district is sustainably managed by the Vashon Island Forest Stewards Council. A forest stewardship project completed by the Council with support from VHS students showed that parts of the 50-acre woods should be thinned and that some trees were at risk of falling. Wood from the forest—including Douglas fir, madrone, maple and alder—was sustainably harvested and milled on island, and appears extensively in the school as stair treads, wainscot and finish trim. Wood finishes and columns were required to have low volatile organic compounds to promote healthful air quality.

Carby Chapel Center

The natural environment was consciously integrated into the design of the Carby Chapel Center near Houston, Texas, through the use of different wood species and a blend of native limestone. Designed and constructed by Roesler Associates, Inc./Architects, it is used for adult retreats and conferences as well as summer camps for children. It functions as a multipurpose chapel and conference center, and also features classrooms and spaces for other camp programs.

Wood used in the chapel was stained and sealed to enhance its natural beauty and provide contrast and visual interest. Custom wood trusses, interior woodwork and trim are Douglas-fir. The exposed structural roof deck is Southern Yellow Pine. The custom designed and built cross, altar, lectern, baptismal font, stair rail, banister, and double entry doors were all made of cedar milled from trees grown on the site.

According to Matt Roesler, AIA, wood was chosen for the interior and exterior because of its aesthetic value, although its acoustic value and natural sound absorption were also important. The orientation of the building

and use of extensive daylighting enhance the natural beauty of interior finishes and provide spectacular natural displays at dawn and dusk. "Musicians in string quartets performing at weddings have said the natural acoustics provided by the wood finishes as well as the baffle effect of the open wood trusses are perfect for wood stringed instruments."

David and Lucile Packard Foundation Corporate Headquarters

Although the David and Lucile Packard Foundation may have a more worldly mission, wood was chosen for its corporate headquarters in Los Altos, California, as a sign of commitment to ideals.

Photo by Lara Swimmer



Vashon Island High School
Vashon Island, Washington
Integrus Architects

At Vashon Island High School, the use of wood throughout and extensive daylighting were key to the strong indoor-outdoor connection desired by the community.

"The inherent warmth of wood was a great match with the client, Packard family members and the Foundation's culture," says architect Marc L'Italien. "It's a very relaxing building to be in and one where the occupant is in constant contact with nature, through views into the outdoor courtyard and being surrounded by natural materials. This palette allowed us to create an environment that's somewhere between a family residence and a retreat center—one that fosters great human interaction and collaboration. It does not feel like an office building and the wood plays a major role in that vibe."

Wood is the main exterior cladding material of the LEED Platinum building and features prominently in the interiors. Selected casework, doors, and furniture utilize eucalyptus veneer salvaged from the Presidio in San Francisco.

The extensive use of wood was a natural choice, expressing the Packard Foundation's commitment to the natural environment and sustainability.

According to L'Italien, much of his firm's work is with institutions, and the firm tends to design 50- to 75-year buildings. "This does guide decisions toward more durable materials that age with grace and require the least amount of maintenance. Whenever we can, we select materials with integral finish, both from a sustainability angle and because there is inherent beauty in well-detailed natural materials. This is one of the most overlooked aspects of sustainability. It's not about the points. It's about designing places where

people want to be. The more they like their environments, the less likely these structures are to be demolished. A strong following and internal flexibility allows them to be repurposed when the users and owners change over time.

"The building is well loved and demonstrates how sustainability can be about more not less. There is no sacrifice here."

BUILDING FOR HUMANS

Wood is a material that consistently brings out the superlatives in building occupants. Research is increasingly confirming a response that most of us feel naturally, without need for explanation. Humans feel good and do well in surroundings that are beautiful and connected to the living green world outside by thoughtfully designed wood materials inside.

ENDNOTES

1. *Wood and Human Health*, Issue 1, FPInnovations
2. *Wood as a Restorative Material in Healthcare Environments*, FPInnovations, 2015
3. *Back to Nature: Can wood construction create healthier, more productive learning environments*, Building Design + Construction, 2005
4. *Approaching the Design and Planning for School Capital Program with Wood*, Mikio Moronuki, Director, Research Center for Educational Facilities, Tomoe Corporation, Japan
5. C. Kelz^{1,2}, Grote V.^{1,2}, Moser M.^{1,2}, *Interior wood use in classrooms reduces pupils' stress levels*, ¹Institute of Physiology, Medical University of Graz, Austria; ²HUMAN RESEARCH, Institute for Health, Technology and Prevention Research, Weiz, Austria

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Go to ce.architecturalrecord.com for complete text and to take the test.

1. The average North American spends what percentage of time indoors?
 - A. 25 percent
 - B. 50 percent
 - C. 75 percent
 - D. 90 percent
2. Wood can improve indoor air quality through which of the following attributes?
 - A. Hypoallergenic
 - B. Absorbs and releases moisture to maintain equilibrium with adjacent air, thus moderating humidity
 - C. Releases into the air beneficial aromatic substances
 - D. A and B but not C
 - E. B and C but not A
3. Wood can amplify or absorb sound, depending on design, and does not present the impact noise transmission issues commonly associated with other materials.
 - A. True
 - B. False
4. Which of the following wall construction typically provides the best acoustic performance?
 - A. Single stud walls
 - B. Staggered stud walls
 - C. Double stud walls
 - D. Concrete block walls
5. How do assemblies with well-designed and installed resilient channels compare to those without, in terms of IIC (impact insulation) and STC (sound transmission) points?
 - A. Assemblies with resilient channels and without perform about the same.
 - B. Assemblies with resilient channels perform slightly better, 1-2 points.
 - C. Assemblies without resilient channels perform slightly better, 1-2 points.
 - D. Assemblies with resilient channels improve acoustic performance by 8-10 points.
6. In some of the projects discussed in this course, which of the following designs used wood to improve acoustic performance?
 - A. Enhanced acoustic wood-frame walls to provide sound control within student housing units
 - B. Sculptural wood wall fins enhancing acoustical distribution in a round conference space
 - C. A wood seating riser to couple with the wood floor of a theater to transmit structure-borne low frequencies to the seats
 - D. All of the above
7. All of the following describe the phenomenon of "biophilia" EXCEPT:
 - A. Humans tend to be more relaxed in outdoor, natural environments such as forests, parks, gardens.
 - B. In order to benefit from biophilia, humans must be in pristine outdoor environments with no man-made structures or other people within view.
 - C. Exposure to nature has been shown to lower blood pressure, heart rate, and aggression.
 - D. Nature increases the ability to focus attention and concentrate on tasks.
8. The physiological benefits of good design have been documented only in healthcare facilities, and "evidence-based" techniques are not applicable to other building types such as schools and offices.
 - A. True
 - B. False
9. In a study described in this course, stress as measured by SNS (sympathetic nervous system) activation was measured in different office environments with wood material and without wood material. Which of the following describes the study findings?
 - A. Stress as measured by SNS activation was lower in the wood room in all periods of the study.
 - B. Finish material in the office environment had no effect on SNS in any of the study participants.
 - C. Stress was lower in the wood room only for a small number of subjects.
 - D. Stress was lower in the room with plain white plastic finishes.
10. Which of the following statements is/are true of wood materials in buildings that are being demolished at the end of their service life?
 - A. Wood can be reclaimed and reused with minor modifications.
 - B. Reclaimed wood used as structural members can be reused for that same purpose.
 - C. Reclaimed wood can be remilled and fashioned into other wood products such as window and door frames, curtain wall components and cladding.
 - D. All of the above



The reThink Wood initiative is a coalition of interests representing North America's wood products industry and related stakeholders. The coalition shares a passion for wood and the forests it comes from. Innovative new technologies and building systems have enabled longer wood spans, taller walls, and higher buildings, and continue to expand the possibilities for wood use in construction. www.rethinkwood.com/CEU