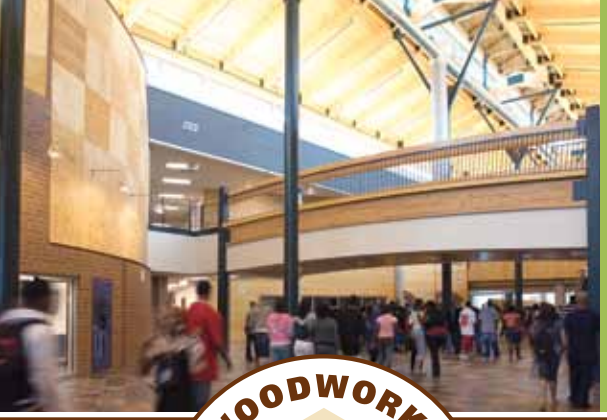


Designing Wood Schools

Wood Design & Building Series

As demand grows and budgets shrink for new educational facilities, many school districts are turning to wood-frame construction for its cost effectiveness. However, they're also finding that, in addition to less expensive material costs, wood offers other advantages—such as speed of construction, design versatility and the ability to meet green building goals—while creating positive learning environments and meeting all code and safety requirements.

When it comes to designing an educational facility, architects and designers must balance the reality of limited financial resources with the desire to provide students with an exceptional learning environment that is warm and enriching. As a result, many are choosing to use wood as both a structural and finish material.

SHW Group, recognized by *Engineering News-Record* as one of the top five education design firms in America, likes to use wood in schools as often as possible. "Our mantra is that learning happens everywhere, not just in the classroom," said Konrad Judd, a lead designer and principal at the firm's Dallas office. "The environments we create outside the classroom are just as critical for learning. That's why we often use wood in common, public spaces which are used for casual and informal learning because we think exposed wood has a positive effect on the overall learning environment."

Wood is an environmentally-friendly, energy-efficient building material approved for use in schools by the International Building Code (IBC). Safety and durability are critically important in school facilities, and wood delivers value on both counts. Wood is also cost effective, saving school districts time and money for both materials and installation costs.

Green Building is Red Hot for Schools

A study released in 2007 by McGraw-Hill Construction found that the education sector was the fastest growing market for green building. The report also noted "an increasingly widespread adoption of policies that require public buildings to have green characteristics."

Widely recognized for its environmental attributes, wood is well-positioned to help schools meet their green building requirements.

Wood is the only major building material that is both renewable and sustainable over the long term—and the only material with third-party certification programs in place to verify that products being sold originate from a sustainably managed resource.

At Andy Dekaney High School in Houston, Texas (above and top of page), architects from SHW Group used exposed wood to create a warm learning environment that positively affects students' sense of community. Credit: Richard Payne Photography

Earn one AIA/CES LU (HSW/SD) by reading this document and taking a short online quiz. For details and learning objectives, visit the Online Training Library at *woodworks.org*. WoodWorks is an approved AIA provider.

School Construction and the IBC

Wood is approved by the International Building Code (IBC) for use in school construction.

- **Building Types I and II** allow the use of Heavy Timber (HT) construction in roof construction and secondary members, which is often used to add visual interest in school entryways, libraries, auditoriums, gymnasiums and other public spaces. Fire-retardant-treated (FRT) wood can also be used in certain applications.
- **Type III** construction allows wood roof and floor systems as well as interior wood-frame walls. FRT wood is required to frame exterior wood-frame walls.
- **Type IV**, also known as Heavy Timber construction, allows use of solid or laminated wood members such as glued laminated timber (glulam), wood decking and structural sheathing when there are no concealed spaces. FRT wood can be used to frame exterior walls.
- **Type V** is the most common type of wood construction, and is allowed for school design. Type V is typically the least expensive type of construction, particularly when load-bearing walls are wood. The IBC allows use of untreated wood throughout a Type V structure. Under the IBC, one-story Type V schools can be up to 87,875 square feet and two-story schools may be as large as 138,750 square feet. If additional square footage is required, two-hour fire-resistance-rated fire walls can be used.

Designing Schools with Wood from APA – The Engineered Wood Association details the approved use of wood in school construction by IBC Building Type. For additional details, refer to the WoodWorks information sheet, *Wood and Building Codes*, available at woodworks.org.

North America has more certified forests than any other jurisdiction and, according to *State of the World's Forests*[1] reports published by the United Nations Food and Agriculture Organization, has as much forested land now as it did 100 years ago.

Independent life cycle assessment (LCA) studies show that wood has significantly less embodied energy than materials such as steel and concrete. Embodied energy is the energy needed to extract, process, manufacture, transport and maintain a material or product. Wood also outperforms other materials in terms of air and water pollution and greenhouse gas emissions, and offers more efficient resource use. And, because wood continues to store the carbon absorbed by growing trees (it is 50 percent carbon by weight), it's an important tool in the fight against climate change.

To better understand the life cycle impacts of their building material choices, designers are increasingly using online tools such as the ATHENA® *EcoCalculator for Assemblies*, which provides LCA data on hundreds of common building assemblies. The *EcoCalculator* is available free of charge from the Athena Institute (www.athenasmi.ca).

Another tool is the carbon calculator, available from the website, *Build Carbon Neutral* (http://buildcarbonneutral.org). David Mount of Mahlum Architects in Seattle uses this site to evaluate the embodied energy of various structural systems. "We enter the school's project parameters, and the calculator gives us a ballpark number of the energy required to build that structure, from the raw material to the building site," said Mount. "Wood always outperforms everything else in our analyses."

How important is the move to use environmentally-sensitive products within school construction projects? "It's very important to us, and to an increasing number of clients," said SHW Group's Judd. "It is important from the standpoint of doing what's right and best for our environment, and to give students who are learning in these environments a sense of its importance. Wood plays into that well, as a renewable, natural resource."

For more information on wood and green building, a variety of materials are available on the WoodWorks website.

Pre-engineered glulam beams were methodically assembled on-site for the Gunter Primary School in Gunter, Texas. At nearly 60,000 square feet, wood-frame construction for the school cost just under $100/square foot. Credit: APA – The Engineered Wood Association

[1] *State of the World's Forests*, 2009, 2007, 2001, 1997, United Nations Food and Agriculture Organization

Wood is Energy Efficient

Wood-frame buildings are energy efficient and, depending on the design, may result in operational savings for the school district over the entire life of the school.

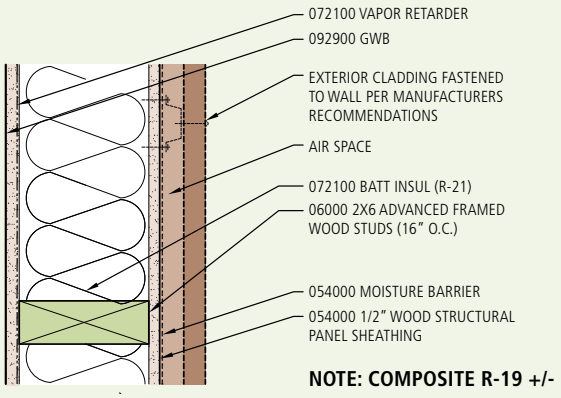
For example, because steel is less resistant to heat flow than wood, steel studs create a bridge for heat transfer through the building envelope. As a result, steel-frame buildings require more insulation to achieve the same thermal performance that wood buildings provide, and even then may cost more to heat and cool. If metal is not thermally isolated, the resulting thermal bridges can also become prime locations for moisture condensation.

Mahlum's Mount said his firm gives strong consideration to wood-frame construction for thermal reasons. "We're seeing a huge difference between steel stud walls and wood stud walls in terms of thermal performance, which reinforces wood's importance in terms of energy conservation. Our office has tested different framing systems in a spreadsheet that measures the energy consumption of an individual classroom. We have not yet translated this to measure the impact on a whole building and total cost savings. However, the differences between wood and other framing materials are big enough to capture our attention."

To illustrate his point, Mount cited two wall assembly drawings used by his firm (see Figure 1). "While they both use R-21 batt insulation, the overall composite R-value for steel studs is R-9, whereas the wood stud wall has a composite R-value of 19. This is a difference just too big to ignore."

According to a study by Keith Kothmann, CPE, *Steel v. Wood, a Cost Analysis of Superstructures*, exterior wall systems also offer thermal benefits when using wood studs instead of metal. Depending on wall height, a metal drywall system can accelerate thermal conductance for 12 to 15 percent of the wall surface, regardless of the amount or thickness of insulation in the wall.

Figure 1



This detail was supplied by Seattle-based Mahlum Architects to demonstrate the thermal properties of wood versus steel. Designers should check with the American Wood Council (e.g., WCD-1 – Details for Conventional Wood Frame Construction) or their local code officials for information on appropriate detailing for specific projects.

Exposed glulam highlights an expansive interior space and provides a finished surface that coordinates with materials used elsewhere in Albert Lea High School, Albert Lea, Minnesota. Credit: APA – The Engineered Wood Association

Warmth of Wood Promotes Learning

Warmth is another reason architects and building designers like to use wood in schools. Many feel that exposed wood enhances learning by providing an inviting and enriching environment. Wood also provides visual interest and softens interior spaces. As a result, it makes learning more comfortable for students than steel or concrete, both of which can have a cold, institutional feel.

Joseph Martinez is principal architect with Martinez+Cutri Corporation in San Diego, California. "The natural warmth of wood does factor into our decision to use it in the public assembly areas of a school," he said. "We want to create a setting where there is some serenity and tranquility. Wood does that, probably the best of any material and certainly better than metal and steel and even painted drywall. Wood has richness and warmth in its grain that tends to put people at ease."

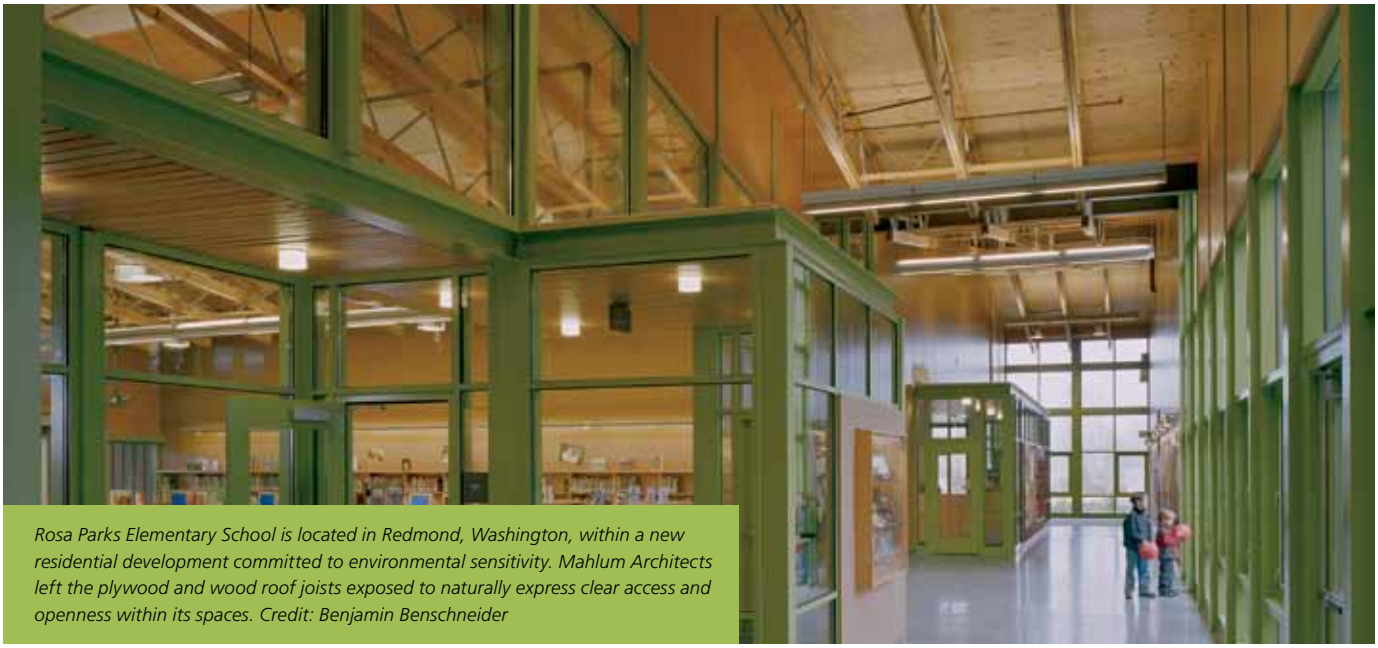
In a three-year study of 700 schools, Japanese researchers studied how the educational environment is shaped by the type of materials used for school buildings, surveying teachers and students to measure their impression of wood versus reinforced concrete. Both groups had similar, favorable impressions of wood schools over concrete. 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.

A 'warm learning environment' is one of the top requests from parents and other advisors in the school design process. According to Mount, the project architect for Rosa Parks Elementary School in Redmond, Washington, "Wood's natural beauty factored significantly in our decision to use it, particularly given the context of this school and its natural environment."

Industry Trends Favor Wood for Future School Design

Most education experts agree that a school's design affects how well students learn and, by extension, how well the school serves its community. A number of current trends favor wood design:

- There is a clear movement toward smaller schools, which are thought by many to promote more effective learning. Type V construction, which allows wood framing throughout the structure, can be a particularly cost-effective option, especially for single-story structures which are less than 87,875 square feet.
- Schools are increasingly used for community events. Wood's natural beauty provides a welcoming environment for public gatherings while instilling civic pride.
- Most architects take a collaborative approach to the design process, seeking input from school and community leaders as well as parents. When asked, most parents say they prefer the warmth of wood for their child's educational surroundings.
- Educators are increasingly grouping students by learning styles, which results in the need for flexible building configurations to accommodate classrooms of various sizes. Wood's design versatility is well-suited to this requirement.



Rosa Parks Elementary School is located in Redmond, Washington, within a new residential development committed to environmental sensitivity. Mahlum Architects left the plywood and wood roof joists exposed to naturally express clear access and openness within its spaces. Credit: Benjamin Benschneider

Wood Construction is Faster

When it comes to building educational facilities, speed pays off. For many school districts and their contractors, the first day of school at a new facility looms large on the horizon. Faster completion and move-in saves school districts money.

Speed is one of the key benefits of wood-frame construction. Wood products are readily available and usually delivered more quickly than steel, which is often shipped from overseas. Wood-frame assembly is fast. Plus, most communities tend to have a large pool of tradespeople with wood framing experience, which affects labor availability and contributes to local economies.

"Wood works particularly well when a project has a tight construction schedule," said Mark Batten, SE, with Burkett & Wong Engineers in San Diego, California. "Contractors can get started right away without waiting for steel shop drawings or steel fabrication. When we design a wood-framed school, we do so primarily because of cost, schedule and speed of construction."

"School construction schedules always seem to be fast track," said Fred Sahs, principal with SAI Architects and the architect and construction manager for the 59,700-square-foot Gunter Primary School in Texas. "With wood, the deliveries are fast and frame assembly moves quickly." Once shop drawings were approved, Sahs said the engineered wood products for Gunter Primary were on the ground in about four weeks.

Stuart Schichtl is with Nabholz Construction, the construction manager and general contractor for Fountain Lake Elementary in Little Rock, Arkansas. "Wood definitely saves time during construction," he said. "We can use local suppliers and local labor, which means greater savings to the district and a benefit for our community. Plus, with a school, it's always important that we meet our move-in deadline."

SHW Group designed the exterior of the two-story Career and Technical Education Center to complement the traditional architectural fabric of Frisco, Texas while presenting a contemporary face for the interior. Credit: Terry Wier Photography

Wood Teaches a $2.7 Million Economics Lesson at Fountain Lake Middle School

When the Fountain Lake School District of Hot Springs, Arkansas made plans to build a new middle school and renovate an existing high school, they had a long wish list but limited financial resources for the 63,362-square-foot project.

According to school board member Bruce Westerman, initial estimates for a masonry and steel building came in over budget, at $150 per square foot including site work and architect/engineering fees. With help from APA – The Engineered Wood Association, the district's Hot Springs-based design team, including architects from Arnold & Associates and structural engineers from B & F Engineering, decided to consider wood framing.

Bids came in for the new wood-frame, two-story middle school and high school renovations at $107 per square foot, saving the district $2.7 million.

Westerman, a practicing Professional Engineer himself, said, "Since we already had voter approval for the project, we really had to make this work and meet our budget. So economics drove the decision to initially consider wood. If we'd been at budget, to be honest, we may not have ever considered a change. But now, we're significantly under budget, thanks to our switch to wood."

Safety First for Schools

Regardless of whether they're built in wood, steel or concrete, schools house our most precious citizens, so safety is paramount.

- Per IBC 903.2.3, sprinklers are required in areas larger than 12,000 square feet in Occupancy Group E building types. Most schools fall into this category. In addition, local building code amendments typically require sprinkler systems and other fire control measures in school construction, regardless of size or framing type.
- Wood has proven superior performance over steel beams in controlled fire tests. Heavy timbers char, which slows combustion and allows extra time for occupants to leave the building.

In some parts of the country, seismic safety is also critically important. It's interesting to note that, in California, one of the most highly regulated states in the U.S. in terms of seismic requirements, roughly 60 percent of schools use wood-frame construction.

"Wood responds well during an earthquake; it provides a lot of flexibility," explained Martinez, who works on projects throughout southern California. "A lot of the schools we've done here use wood-frame construction because wood is well-suited to deal with lateral loads and California's seismic requirements."

Wood Schools Offer Decades of Durable Performance

Schools get a lot of abuse, so durability of finish materials is important. While numbers vary around the country, elementary schools typically have an expected lifespan of 50 or more years. In many cases, interior and exterior finishes serve as the primary drivers of the structural framing material choice. For example, painted masonry is perceived as the most durable choice for interior common areas like corridors. However, the results often have a cold, institutional feel.

"We need to balance a facility's maintenance needs with good design ethics," said architect Mount. "Unfortunately, some districts have a mistaken impression that a school has to be indestructible. We have seen plenty of examples of schools where their seeming only goal was to minimize maintenance, but they did not promote learning."

Versatility is also important. "Wood framing allows you to use a variety of architectural finishes and treatments that you can't use with a masonry wall," said Batten. "There are many affordable options for treating and protecting surfaces."

Westerman of the Fountain Lake Middle School in Arkansas said the only legitimate hurdle they ran into regarding durability using wood was for interior corridors. "We worried about kids knocking holes in the gypsum wallboard," he explained. "We easily overcame that by installing OSB (oriented strand board) over the wood studs and then covering it with impact-resistant gypsum to provide protection."

The inviting entrance to Chloe Clark Elementary in DuPont, Washington welcomes children while complementing the surrounding community. Credit: APA – The Engineered Wood Association

Extra Credit Benefits of Wood

In the quest to balance all the demands of a school facility, several other benefits of wood come into play.

- Wood offers design flexibility, allowing designers to cost-effectively achieve long spans for open spaces or shorter spans for more intimate spaces.
- Structural versatility is important, since school additions and alterations have traditionally outpaced new construction by a ratio of 4 to 1, according to McGraw-Hill Construction. Wood framing is easy to modify, whereas steel and concrete may require demolition and/or major retrofitting, at considerable expense.
- Wood surfaces provide good sound absorption, a feature school administrators appreciate. Wood has more sound damping capacity than many other structural materials. Excellent levels of noise control can be achieved with good acoustical design in wood-frame structures surfaced with wood structural panels.
- Insurance for wood buildings may be considerably less than for other structures. "We were surprised to discover that our facility insurance would cost less with the wood-frame alternative," said Fountain Lake School District's Westerman. "Our buildings are insured based on replacement cost of the structure itself and, since this school will cost $2.7 million less to build, we'll save money on insurance for years to come."

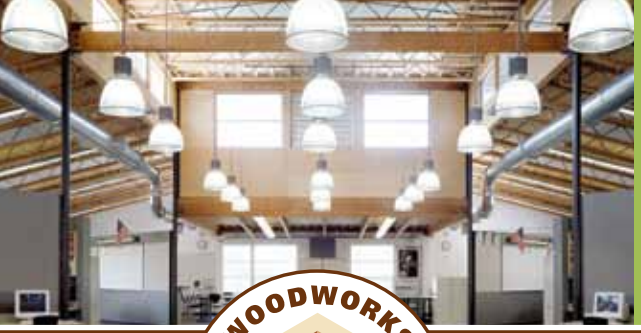
Lessons Learned

Warm and friendly interiors, environmentally-friendly materials, long-term energy savings, speedy construction, safe and durable schools—wood provides many advantages for school districts seeking to maximize their facilities budgets.

"Wood provides a very rich and enlightened environment for learning," said Martinez. "Whether it is featured as an architectural element in the library, or used for the structure in a multipurpose room, wood is very soothing."

Westerman added, "Here in Hot Springs, we made a rational observation and made a logical choice to use wood for Fountain Lake Middle School. We saved millions of dollars for the district by switching to a wood-frame structure. I now also look back and think that, even if price had been the same, wood offers enough other advantages that we might still have gone this way."

Wood's design versatility complemented the traditional styling of Brook Hill Elementary in Bullard, Texas. The 31,000-square-foot structure was built at a cost of $127 per square foot in 2006. Credit: APA – The Engineered Wood Association



The Economics of Wood in School Design and Construction

woodworks.org

As school districts' construction budgets tighten, education and community leaders find themselves increasingly pressured to provide enriching learning spaces that are environmentally friendly, safe, easy to maintain and affordable. Wood-frame construction meets all of these requirements, and is proving to be a cost-effective option for school districts, both in terms of initial construction and lower energy costs that can be realized over the life of the structure.

Cost Comparison: Wood-frame vs. Steel-frame

To see how the cost of a wood-frame school compared to steel, Keith Kothmann prepared a cost analysis for a one-story, 73,557-square-foot elementary school which had been built in 2002 in Flower Mound, Texas. Kothmann is a Certified Professional Estimator, an engineer and former general contractor from Fort Worth, Texas, with more than 25 years of construction experience.

To provide a fair comparison with no design or appearance changes except the gym ceiling, Kothmann compared three wood framing options to the as-built post and beam steel structure.

His results showed that the initial cost of construction could be substantially reduced by changing the superstructure of the school from steel to wood. Kothmann's study also determined that the life cycle savings realized from the additional thermal resistance provided by the wood roof system would save the district $15,000 or more per year in energy costs, which is in addition to the reduced energy consumption from the wood-framed walls.

KOTHMANN REPORT FINDINGS

	Savings per Square Foot	Total Savings	% Savings over Steel	Annual Energy Savings with Wood Walls	Completion Time Savings
Option A: Wood roof framing with metal studs (Type IIIA) • Steel columns remain • Change from steel to glulam beams • Change from steel bar joists to wood I-joists • Change from metal deck to rated sheathing	$2.36	$173,797	13.92%		Saves 2 weeks
Option B: Wood roof framing with wood studs (Type VA) • Steel columns remain • Change from steel to glulam beams • Change from steel bar joists to wood I-joists • Change from metal deck to rated sheathing	$2.82	$207,160	16.6%	$1,300	Saves 5 weeks
Option C: Wood roof system with load-bearing wood stud walls (Type VA) • Change from post and beam framing to wood I-Joists bearing on top of wood stud exterior and interior walls • Change from metal deck to rated sheathing	$6.07	$446,284	35.76%	$1,300	Saves 12 weeks

Cost of Materials

Results from the Kothmann study were based on June 2005 numbers. According to the Construction Materials Price Index, published by the U.S. Department of Labor – Bureau of Labor Statistics, the difference between wood and steel increased by a factor of 3.5 between 2005 and 2008, making the $446,284 savings from Option C calculated in June 2005 worth more than $1.5 million dollars in 2008. Since the cost of building materials fluctuates with the market, actual savings realized by switching to a wood-frame structure may be different today.

Speed of Construction

Duration of construction is another key consideration in facilities planning. The Kothmann study analyzed the direct cost of reducing construction time by building a wood-frame rather than steel-frame or concrete facility.

The study found that the project duration of the wood-frame Option A is two weeks less than a conventional steel structure. Wood-frame Option B saved five weeks, and Option C resulted in completion 12 weeks earlier than a steel-frame building. While the study did not calculate the benefits of earlier occupancy, there are obvious financial benefits associated with a shorter construction schedule.

Wood-frame construction is faster than steel for a number of reasons. Most wood building materials are locally available, requiring no long lead times for delivery. Plus, wood-frame assembly is fast; contractors can often install wood members using boom trucks and other readily available construction equipment instead of cranes, which speeds construction and further reduces cost.

Life Cycle Costs

The Kothmann Study also compared the life cycle costs of the various structural systems in terms of HVAC operational costs, and found that wood framing provided significant energy savings over the life of the building.

Wood is naturally more resistant to heat flow than steel, which makes it more energy efficient. Additional energy savings were realized from reduced roof insulation. In low-sloped roofs, dead air space offers insulation which lowers the required R value of the rigid insulation used on top. However, if R19 rigid insulation is still used with a wood roof structure, the project will realize additional energy savings. Lower energy bills would save a building owner $15,500 per year, according to Kothmann. When amortized over the life of the building, savings from using wood framing in a school become significant. If radiant barrier sheathing is used over the dead air space in a roof structure, savings may be even more, particularly in warm climates, because it reduces heat flow in and out of the conditioned space.

Gunter Primary School in Gunter, Texas includes exposed beams in the cafeteria and gymnasium for a visually stunning effect. Credit: APA – The Engineered Wood Association

IBC CONSTRUCTION TYPES AND ICC BUILDING VALUATION DATA

Under the International Building Code, Type V Construction (the most common type of wood construction) can be used for school design and construction and allows use of untreated wood throughout the structure. Type V construction requirements allow total building areas up to 87,875 square feet for single-story and 138,750 square feet for two-story structures. These buildings must be sprinklered, have one-hour fire-resistive-rated walls/floors/roofs, and have a minimum 30-foot setback on all sides. Two-hour fire walls can be used if additional square footage is required for Type V buildings.

The International Code Council (ICC) provides members with periodic updates for their Building Valuation Data (BVD). The BVD data details average construction costs per square foot for various types of construction. Data clearly shows the economic advantages of Type V construction.

Square Foot Construction Costs / 2006 IBC

		Type of Construction								
Group		IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
E	Educational	$176.25	$170.31	$165.46	$158.26	$148.32	$140.74	$153.03	$130.54	$125.61

Source: Building Safety Journal, January-February 2009

Front page photo: Designed to serve at-risk teens, the 23,300-square-foot Truman High School in Federal Way, Washington had a tight construction budget, so Mahlum Architects balanced an exposed structure with the warmth of wood to create a vibrant common space. Credit: Benjamin Benschneider

SOURCES AND OTHER MATERIALS

Wood Schools

APA – The Engineered Wood Association, www.apawood.org

- *Case Study: Albert Lea High School case study (Form No. EWS B115)*
- *Case Study: Gunter Primary School (Form No. G170)*
- *Case Study: Las Vegas Elementary School (Form No. F120)*
- *Case Study: Liberty High School (Form No. Y115)*
- *Case Study: National Heritage Academy (Form No. A110)*
- *Engineered Wood Construction Guide (Form No. E30)*
- *Engineered Wood in School Design (Form No. B210)*
- *Wood Construction Nets $2.7M Savings for Arkansas School District (News Release)*
- *Wood Facts: Designing Schools with Wood (Form No. J335)*

Other Sources

- *Approaching the Design and Planning for School Capital Program with Wood*, Mikio Moronuki, Director, Research Center for Educational Facilities, Tomoe Corporation, Japan
- International Code Council *Building Valuation Data*, January-February 2009
- McGraw-Hill Construction Education *Green Building SmartMarket Report*, 2007
- *Steel v. Wood, a Cost Analysis of Superstructures*, Keith Kothmann, CPE, Construction Cost Management Co.
- U.S. Department of Labor *Construction Materials Price Index*

Additional Information

American Wood Council/American Forest & Paper Association, www.awc.org

Canadian Wood Council, www.cwc.ca

Forestry Innovation Investment, www.naturallywood.com

FPInnovations – Forintek Division, www.forintek.ca

Natural Resources Canada, http://canadaforests.nrcan.gc.ca/?lang=en

Southern Pine Council, www.southernpine.com

USDA Forest Service, http://www.fs.fed.us/

Western Wood Products Association, www2.wwpa.org

Life Cycle Assessment and Sustainability

Athena Institute, www.athenasmi.ca

Build Carbon Neutral, www.buildcarbonneutral.org

Consortium for Research on Renewable Industrial Materials, www.corrim.org

State of the World's Forests, 2009, 2007, 2001, 1997, United Nations Food and Agriculture Organization

The State of America's Forests, M. Alvarez, 2007, Society of American Foresters

WoodWorks is an initiative of the Wood Products Council, which includes all of the major North American wood associations.