Wood-Frame Schools: Durability Techniques for Interior High Traffic and Moisture Areas

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Wilkes Elementary School
Bainbridge Island, WA
Mahlum Architects

Photo: Benjamin Benschneider

Ask any group of design professionals, school facility planners or maintenance personnel to discuss the primary design objectives for school construction, and the topic of durability will arise. Specifically, they point to the challenge of creating structures that last (a common goal is 50 years or more[1]), while minimizing the time and cost associated with maintenance and repairs, and allowing the school to remain open and safe at all times.

Wood-frame schools can be highly durable; around the world, many wood buildings 50 to 100 years old (and much older) are still in service, including school facilities. For example, Lincoln High School in Tacoma, Washington, a wood-frame building with masonry veneer, was built in 1914 and renovated in 2007. Hanover Street Elementary School in Lebanon, New Hampshire, a wood and masonry-frame structure, was built in 1951. Both of these facilities are still in service.

Durability of any structural material comes down to the surrounding environment (e.g., moisture, temperature, and relative humidity), ability to dry if it becomes wet, and quality of details and control layers. Designing for a long service life means anticipating potential durability issues and implementing strategies to avoid them.

This paper will examine two of the most significant durability challenges when designing wood-frame schools: areas of high traffic and high moisture. It also includes a discussion related to the durability of exposed heavy and mass timber elements, which are often used as a design feature to bring wood's natural warmth into the learning environment.

High Traffic Areas

Without durable finish materials, it doesn't take long for surfaces in high traffic areas to be extensively damaged. Examples include public corridors and stairs where students are running and scraping backpacks against the walls, and gyms where balls are being thrown and kicked.

While gypsum wallboard is often used as a finish in wood-frame wall assemblies to meet criteria such as fire resistance and acoustics, it is prone to damage from impact, scratches and moisture. It is easily repaired in patches, but this can be costly and time consuming, and is less than ideal for school facilities.

As an alternative, many school designers create higher-durability walls through the use of finishes such as:

- Hard tile
- Medium density fiberboard (MDF)
- Impact-resistant gypsum (compliant with ASTM C1629)
- Vinyl wall coverings
- Wood structural panel finish or backing to the finish material

At El Dorado High School, hard tile covers the lower 6 feet of corridor walls and stairwells.

Photo: CADM Architecture

To make these finishes cost-effective, it is important to consider where they are most effective and where they may be unnecessary. For example, some designers use a high-durability finish only on the lower portion of walls—i.e., the bottom 6 feet. Above this, the wall would be unlikely to suffer from significant wear and abuse, so omitting these higher-durability finishes and using only gypsum wallboard makes sense. Installing durable finishes on just a portion of the walls also offers an opportunity for color and textural accents.

Jim Hansen, Director of Construction and Planning Emeritus for the Bethel School District in Washington State, says a common detail is to use MDF panels in 2'x 4' sheets, set in a running bond pattern with beveled edges, to protect the lower half of corridors. This District regularly chooses wood-frame construction for its schools.

At Shining Mount Elementary School, corridor wall finishes include MDF, vinyl and gypsum. MDF is also used on the lower section of gymnasium walls.

Photo: Jim Hansen, Bethel School District

Mark Batten, SE, with Burkett & Wong Engineers in San Diego, California, notes the flexibility that wood allows in finish selection. "Wood framing allows you to use a variety of architectural finishes and treatments that you can't use with a masonry wall. There are many affordable options for treating and protecting surfaces."

Similarly, the Bethel School District frames all of its gym walls with wood studs covered with MDF on the inside. Discussing the success of this approach, Hansen says, "A lot of districts use concrete in the gym because they think they need it for durability, but concrete is hard to insulate. We can easily control temperature because we super insulate that space. And durability is no problem because we use MDF to protect the walls."

The use of wood structural panels as a backing to finishes is also a viable option. In many cases, they may already be required in a wall assembly as part of a lateral load-resisting shear wall. If this is the case, simply choosing to install the panels on the higher traffic side of the walls can make them double as a durability component.

Bruce Westerman, a Professional Engineer and past school board member of the Fountain Lake School District in Hot Springs, Arkansas explained why this detail was chosen for one of their school facilities. "We worried about kids knocking holes in the gypsum wallboard. 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."

One question that may arise with this option is whether the addition of wood structural panels to fire resistance-rated wall assemblies is permitted. There are several sources that indicate yes, including Underwriter Laboratories' General Information for Fire-resistance Ratings – ANSI/UL 263 (Section VI, Item 6),

Tile wall finish is used in the bathroom area at Spanaway Middle School.
Photo: Jim Hansen, Bethel School District

At Morris E. Ford Middle School, exposed wood columns are raised off the floor to protect against moisture.
Photo: Andrew Buchanan for Erickson McGovern Architects

ICC-ES Report ESR-2586 and Rule 2 of the 10 Rules of Fire Endurance Resistance Ratings described in the American Wood Council's document, *Design for Code Acceptance 4, CAM for Calculating and Demonstrating Assembly Fire Endurance.*

High Moisture Areas

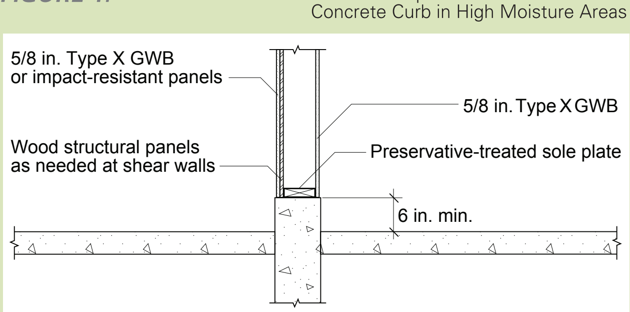
As with other materials, wood can deteriorate if used inappropriately. However, as noted above, suitable detailing, along with proper construction techniques and adequate maintenance, can result in many decades of reliable service—even in interior areas of high moisture.

Wood is a hygroscopic material, which means it naturally absorbs and releases water to balance its internal moisture content with the surrounding environment. The moisture content of wood is measured by the weight of water as a percentage of the oven-dry weight of the wood fiber.

Water by itself does not harm wood, but wood with consistently high moisture content enables fungal organisms to grow. Once decay fungi are established, the minimum moisture content for decay to propagate is 22 to 24 percent, so building experts recommend 19 percent as the maximum safe moisture content for untreated wood in service.

The key to avoiding decay and reducing maintenance is keeping the wood "dry by design"—i.e., implementing strategies to prevent water from accessing wall, floor and roof assemblies. For example, in areas such as bathrooms, labs and kitchens where floors are often wet, it is prudent to elevate the wall structure and finishes. A common approach is to install a minimum 6-inch-tall concrete curb under the walls. In addition to protecting the structure, the objective is to avoid costly and time consuming repair associated with non-moisture-resistant finishes that have been exposed to moisture. Another approach is to use durable finish materials, which also increase a wall's durability related to moisture. A common example is the use of hard tile on the lower portion (typically 6 to 8 feet) of bathroom walls.

FIGURE 1: Example Detail: Raised Wall on Concrete Curb in High Moisture Areas



Best Practices for School Durability

Design and Construction

There are four recommended ways to protect wood-frame structures against durability hazards and help ensure maximum service life for the building:

- Avoid the potential effects of moisture and abuse using design techniques discussed in this document.
- Provide effective control of termites and other insects.
- Use durable materials such as preservative-treated or naturally durable species of wood where appropriate.[2]
- Provide quality assurance during design and construction and throughout the building's service life using appropriate maintenance practices. Examples include regularly scheduled construction site visits by all members of the design team, construction inspection and testing services as required by Chapter 17 of the International Building Code and deemed appropriate by the owner and design team, and routine maintenance checks of areas prone to moisture, damage and termite issues (such as the base of exterior walls and interior high moisture and traffic areas).

Maintenance

Examples of practices that may contribute to extended service life include the following:

- Keep exposed wood properly painted, stained or otherwise protected.
- Periodically inspect both the inside and outside of raised foundation walls; watch for termite tubes, little piles of wood dust, or obvious insect activity.
- Know the useable life of applied termiticides and retreat as recommended.
- Keep heavy brush or shrubbery away from exterior walls.
- Point exterior sprinkler systems away from wood walls.
- Keep roof gutters unclogged and running freely.

According to Jim Hansen, most Bethel District schools are in single-family residential zones, so they use sloped roofs and natural but durable materials on the exterior. Pointing out that wood lends itself well to surface treatments, he said, "Kids like color, and a good bucket of paint costs $30 or $35 a gallon. If it's applied correctly, that paint will last 12 to 15 years or longer. If you want to change it or update to a more current color scheme, it's relatively inexpensive to do. If you paint on metal or concrete, it becomes a long-term maintenance issue, since neither holds paint as well as wood."

Wood in Exposed Applications

For exposed applications such as gym or library roofs, high traffic isn't a concern and moisture can be addressed with proper envelope detailing and mechanical system design. However, heavy and mass timber can also be successfully used in wall and floor/ceiling applications.

Where exposed wood framing is used in high traffic or moisture areas, the design best practices associated with traditional wood-frame construction still apply.

For the gymnasium of Washington Latin Public Charter School in Washington, DC, for example, architecture firm Perkins Eastman chose cross-laminated timber (CLT) panels and glued-laminated timber (glulam) columns and beams. To address durability concerns, a steel base plate was used to prevent moisture from the slab-on-grade from getting to the CLT wall panels, and a fluid-applied air/vapor barrier was used on the exterior of the panels for weather-proofing. Padding on the lower portion of the walls was added for athlete safety, but also protects the walls from damage due to gym activity.

The multi-use student commons building at the Morris E. Ford Middle School in Washington State is another example. Designed by Erickson McGovern Architects, which designs many of the Bethel School District Schools, the building includes a mix of dimension lumber framing, I-joists, glulam and laminated veneer lumber. In the photo on page 3, exposed wood columns are raised to protect them from moisture intrusion from the slab-on-grade below.

Safety padding on the lower portion of gym walls at Washington Latin Public Charter School also protects from damage.

Photo: ©Sarah Mechling, courtesy Perkins Eastman

Termite Control

Although not a focus of this document, in certain regions of the country termite control can be a major consideration related to the durability of wood-frame structures. Best practices for controlling termites are listed in the Best Practices for School Durability sidebar on page 3. Additional information can also be found in the following resources: Termite Control and Wood-Frame Buildings by the Canadian Wood Council, Design of Wood-Frame Structures for Permanence by the American Wood Council, and Termite Protection for Wood-Framed Construction by APA – The Engineered Wood Association.

Conclusion

Proper finish selection and detailing at high-traffic and high-moisture areas can lead to durable wood-frame school facilities, which allows designers to realize many other benefits of using wood in schools. Wood-frame construction can be more cost effective than other building systems, while meeting all code requirements for safety and performance, and offering advantages such as renewability, a relatively light carbon footprint, and thermal efficiency. Increasingly, the use of exposed wood in schools is also being recognized for its contribution to a warm and enriching learning environment.

Resources and Project Support

For more information on the design of wood schools, WoodWorks offers a variety of publications, presentations and other resources via its education resource page at www.woodworks.org/design-and-tools/building-types. The reThink Wood CEU, Designing Modern Wood Schools, can be found at www.rethinkwood.com/sites/default/files/Designing_Modern_Wood_Schools_CEU.pdf.[3] WoodWorks also offers free one-on-one project assistance related to the design of any non-residential or multi-family wood building, including schools. Visit www.woodworks.org/project-assistance to contact the technical expert nearest you or email help@woodworks.org.

End Notes:

[1] 2016 State of Our Schools: America's K-12 Facilities, a joint publication of the 21st Century School Fund Inc., U.S. Green Building Council, Inc. and National Council on School Facilities

[2] For more information, a variety of materials related to durability and wood buildings are available from the Canadian Wood Council at www.cwc.ca/design-with-wood/durability/.

[3] For more information, a variety of CEUs and case studies related to durability and wood use in the U.S., visit www.rethinkwood.com.

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