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NEWSLINE

Forest Products Laboratory

Preventing crawl-space moisture buildup in Gulf Coast homes

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For twelve months, Sam Glass's research team spent a lot of time on hands and knees. As a Forest Products Laboratory (FPL) research physical scientist, Glass led an investigation on insulation used under raised-floor homes in southern Louisiana between October 2008 and October 2009. In a cooperative endeavor with the Louisiana State University (LSU) AgCenter, Glass and a team of researchers monitored conditions in a dozen homes to evaluate the effects of insulation on moisture migration in wood subfloor components. What they discovered will help homeowners and builders improve energy efficiency and durability in hurricane and flood zones throughout the Gulf Coast.

"A hot and humid climate, such as southern Louisiana's," says Glass, "can be a challenge for wood-framed construction if moisture management is not carefully considered."

Of the dozen homes monitored, eight were in New Orleans and four were in Baton Rouge. The houses in New Orleans were all built by New Orleans Area Habitat for Humanity following the devastation of hurricanes Katrina and Rita. These houses, all in the Musicians' Village neighborhood of the Upper Ninth Ward, had similar floor plans and were built of comparable materials. Of the Baton Rouge homes, one was built in 2002, one around 1950, and two prior to 1930.

Concurrent with the effort to rebuild Gulf Coast communities, Professor Claudette Reichel of the LSU AgCenter sought out partners to perform research on this issue.

"Most prior crawl-space research had been done on sealed, conditioned spaces," says Reichel. "In many parts of the country, that works well, but it's not a good idea in a flood hazard area."

After Katrina and Rita, new codes and ordinances stressed the need for building raised home foundations with insulated floors. "In the past, there typically wasn't insulation under raised homes, but many who insulated their floors for comfort and energy savings ended up with problems such as wood decay or buckled floors from moisture accumulation," says Reichel.

Houses with pier foundations constructed by Habitat for Humanity in New Orleans, LA.

Several organizations expressed interest in studying the use of alternative wood-floor insulation systems for affordable, durable home construction. Industry groups including APA –The Engineered Wood Association, and the Southern Pine Council partnered with FPL and LSU in this project.

Because of the generally high water table in the Gulf Coast, basements are rare. Houses are usually built with a crawlspace (raised-floor), slab-on-grade, or raised slab foundation. Raised-floor homes are often elevated three feet off the ground or higher when located in a flood zone.

Raised-floor houses along the Gulf Coast are often built on concrete or block piers or perimeter walls. Wall-vented crawl spaces have a perimeter wall, continuous around the home, with vents to the outside. Open-pier crawl spaces have no perimeter wall except perhaps a decorative wall in front of the house. Eleven houses in this study had open-pier crawl spaces; one had a wall-vented crawl space. All were single story homes.

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Upcoming Events

Forest Products Society's 64th International Convention

June 20–22, 2010 Madison, Wisconsin

The Forest Products Society's 64th International Convention will feature industry, university, trade association, and government leaders speaking on the future direction of forest products research and development. This stimulating forum will highlight creative contributions by the research and development community and lay out plans for new and emerging technological advances. The concurrent technical sessions offer great opportunities for industry, academic, and government professionals to network and learn about the latest research results. For more information, visit www.forestprod.org/.

Society of Wood Science and Technology, 2010 International Convention

October 11–15, 2010 Geneva, Switzerland

The Society of Wood Science and Technology will hold its 2010 International Convention in Geneva, Switzerland at the Palais des Nations together with co-hosts the United Nations Economic Commission for Europe–Timber Committee (UNECE–TC), on October 11–15, 2010. The theme of the convention is "Role of Wood Science in the Green Building Movement." You can view all conference information at http://www.swst.org/meetings/AM10.

Wood You Believe...

- There are 751 million acres of forests in the U.S. – roughly one third of its total land area.
- Forest area has been relatively stable since 1910.
- Over 75 million acres of forests are reserved for non-timber use, such as parks and wilderness areas.
- The average volume of growing timber per acre is rising. In some areas, the volume per acre is nearly double what it was 50 years ago.

From USDA Forest Service Forest Inventory and Analysis National Program

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The ground in a wall-vented crawl space, given the often high moisture content of the soil, should always be covered with a vapor barrier such as polyethylene, according to Glass. In all cases, the soil around the foundation should also be graded so that water drains away from the building.

"If a building is air-conditioned and it's warm and humid outside, water vapor migrates from outdoors to indoors," says Glass. "It makes sense then that subfloor insulation should be chosen to best resist that flow of moisture."

The factors Glass and his colleagues found most related to moisture content in the subfloor included the type of crawl space insulation, level of indoor temperature, and type of interior floor covering or finish. "The insulation was what we were most interested in," says Glass.

"In some houses we left fiberglass batting in place. It's commonly used," says Glass. "That's what the Musicians' Village houses had." In these homes, researchers took out half of the fiberglass insulation and replaced it with rigid foam or spray foam insulation. Floors in the Baton Rouge houses were insulated entirely with rigid foam or spray foam.

Cooler indoor temperatures from air-conditioning in the summer months can lead to higher moisture content in the subfloor. During the winter, the difference between indoor and outdoor humidity levels is negligible.

"Two things are going on there," says Glass. "First, the more you're air-conditioning, the more you also dehumidify that air. This results in a larger inward vapor drive. The second factor is a lower subfloor temperature; the lower the temperature, the more the subfloor becomes prone to moisture accumulation."

"Over the twelve houses we studied was a range of indoor temperature set points," Glass says. "We actually measured this with data loggers for accuracy. The values ranged from averages of 70° F to 80° F during summer. By cooling a house down to 70°, everything inside the house drops below the outdoor dew point temperature." The dew point is the temperature at which water vapor in the air starts to condense into liquid.

"If the indoor temperature is 70° F, and it's 85° F outside with a 75° F dew point," says Glass, "there is definitely potential for condensation on your floor if there's nothing to resist water vapor moving from the air into your subfloor." This is where insulation becomes effective; to provide resistance against the flow of water vapor.

Homeowners in sub-tropical climates such as Southern Louisiana are encouraged not to set the thermostat below the outdoor dew point. In these areas, the July average outdoor dew point is about 74° F. Thermostat settings of 76° F or higher not only reduce the risk of moisture problems in subfloors, they also result in less energy consumption. If comfort is an issue at such temperatures, homeowners might consider ceiling fans to increase airflow and a stand-alone dehumidifier to lower the indoor humidity.

This pier foundation supports a raised floor framed with pressure-treated lumber.

Glass and his colleagues generally found that more permeable insulation resulted in higher subfloor moisture content. Aluminum foil-faced foam board, for example, is basically impermeable to water vapor. Closed-cell spray foam insulation is semi-impermeable. Open-cell spray foam and fiberglass insulation are much more permeable. Greater permeability allows for water molecules to migrate through insulation and into subfloor materials.

According to Glass, staying below a 16% – 18% threshold of moisture content in wood subfloors helps avoid the formation of mold or corrosion. Closed-cell spray foam was found to be more reliable for preventing moisture migration on a wider variety of environmental conditions than the open-cell foam.

"The open cell spray foam insulation resulted in some cases where moisture content rose above 20 percent," says Glass. "We felt that this type of insulation was unreliable for stopping moisture migration, especially when indoor temperatures are set lower than about 78°F."

In homes with higher indoor temperatures during the humid summer months, however, "The open-cell spray foam performed just fine," says Glass. Those same results were found with fiberglass insulation. In other words, for the same conditions where the open cell foam didn't perform well, those with lower indoor temperatures, fiberglass batting performed similarly.

Glass informed us that fiberglass doesn't provide resistance to water vapor. Rather, it is the kraft paper facing,

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right below the subfloor that provides some resistance. However, the kraft facing becomes more permeable as relative humidity increases, and in the south, the outdoor relative humidity is commonly above 80 percent.

The role different indoor floor finishes play in subfloor moisture levels also interested Glass and his colleagues. "We found higher moisture levels with vinyl floor covering compared with carpet."

"This was expected," says Glass. "Vinyl is very impermeable so moisture can't really move through the subfloor. Any moisture getting through the insulation into the subfloor stays there because vinyl is basically a moisture barrier."

Carpet, on the other hand, is somewhat permeable for water vapor. The advantage of a permeable finish instead of vinyl is less likelihood of moisture buildup in the subfloor.

In a few instances, open-cell foam was finished with a coat of vapor-retarding paint. Using a combination of products such as this may appeal to homeowners because open-cell foam plus paint is less expensive than closed-cell foam alone. In carpeted floors, where subfloor moisture contents were relatively low, this type of paint had no discernable effect, according to Glass. However, in floors finished with vinyl, open cell foam with the vapor retarding paint maintained lower moisture content in the wood subfloor than open cell foam without the paint, based on the limited sample of houses in the study.

"We looked at a limited number of insulation options," says Glass, "but based on what we found, closed-cell foam is probably the easiest type to use." Installing foil-faced rigid foam can be a challenge in the tight confines of a crawl space.

Glass recommends a crawl space height of at least 36 inches for building a new raised-floor home, just for accessibility alone. When building in a flood zone, one may want to go higher than the flood elevation to lower the risk of flooding and to reduce insurance premiums.

Builders and insulation contractors should design and construct houses with durability, not just economy, as a goal. "Homes should be able to handle cooler than average indoor temperatures in the summer and handle floor finishes like vinyl tile, because it's very commonly used," says Glass.

To combat uncontrollable elements such as high outdoor humidity, homeowners and builders should use an impermeable insulation as a barrier against moisture migration. Limiting the amount of vinyl flooring (or other impermeable floor finishes) inside a home and keeping indoor temperatures above the outdoor dew point will also prevent moisture buildup in the subfloor. "With these factors in mind," Glass says, "homeowners along the Gulf Coast region can continue to rebuild their communities with both comfort and durability in mind."

FPL Researcher Named Chair of ASTM Wood Committee

David E. Kretschmann, research general engineer at the Forest Products Laboratory, has been elected as the Chairman of ASTM International Committee D07, a 300-member committee that oversees 89 standards related to forests, timber, wood, modified wood, veneer, and more that are published in the Annual Book of ASTM Standards. Kretschmann also leads the terminology and editorial subcommittee as well as the group on solid sawn timber. ASTM International is one of the largest international standards development and delivery systems in the world and its standards are accepted and used in research and development, product testing, quality systems and commercial transactions.

Biofuel Production from Woody Biomass Improved with New Pretreatment Process

By Rebecca Wallace
Public Affairs Specialist, Forest Products Laboratory

A major barrier to the commercial development of biobased fuels and products from woody biomass is being addressed thanks to a joint research effort between the USDA Forest Service, Forest Products Laboratory (FPL) and the University of Wisconsin-Madison (UW).

FPL and UW researchers have developed a novel process that helps overcome the natural resistance of biomass to enzymatic deconstruction. Processes that can efficiently convert woody biomass to ethanol are lacking, in part, because of the recalcitrance of plant biomass, or the inability to efficiently convert cellulose to glucose, a necessary step in ethanol production.

The newly developed process is sulfite pretreatment to overcome recalcitrance of lignocellulose, or SPORL. According to FPL research general engineer JunYong Zhu, "Despite much research and development success in the area of biofuels, there is still a lack of commercially viable pretreatment processes for cellulosic ethanol production from woody biomass, especially from softwoods." The challenge is that solutions need to be both technically feasible and economically viable in a market-based system.

"SPORL is only the second known pretreatment process for efficiently converting softwoods," says Zhu. "Softwood tree species are dominant in several parts of the United States, Canada, New Zealand, and northern Europe, so it is important to the success of woody biomass conversion that we are able to utilize this resource."

And success is what Zhu and his team are continuing to find. Partnering with the USDA Agricultural Research Service (ARS), FPL and UW researchers were able to reach a milestone ethanol yield of 276 liters (73 gallons)/metric ton of wood from lodgepole pine thinnings. Moreover, net ethanol energy (lignin energy not included) output before distillation was 4.55 GJ/ton wood based on preliminary energy balance analysis.

SPORL addresses other critical issues associated with woody biomass conversion. For example, the pretreatment significantly reduces the energy consumption needed to physically reduce the size of woody biomass.

The ability to utilize softwood species is key to the commercial development of biobased fuels and products from woody biomass.

"The reduction of energy consumption using the SPORL treatment sequence reduces the energy needed for size reduction to about the same level as that required with agricultural residuals used for biofuel production," says Zhu.

SPORL was developed on the basis of sulfite pulping technology, which has been carried out at a large commercial scale for decades. According to Zhu, mills with the capacity to process 1,000 to 2,000 tons of woody biomass per day could instead produce 30 to 60 million gallons of ethanol per year.

"SPORL should have excellent commercial scalability," says Zhu. "By making use of existing equipment, processes, and knowledge of the pulp and paper industry, SPORL presents fewer technical barriers to building new plants or to retrofitting existing pulp mills to production of biofuels."

Furthermore, SPORL should also have excellent potential for co-production of value-added products. SPORL produces a sulfonated lignin that is used in a variety of applications with established markets. The potential for co-products should improve the viability of producing biofuels from woody biomass.

This research has been published in *Bioresource Technology* and *Applied Microbiology and Biotechnology.*

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