News of Interest for and from the Connecticut Association of Home Inspectors, Inc.

CAHI MONTHLY NEWS

November 2020 Volume 13, Issue 11

Presidents Corner

Years and years ago when the internet first took hold and dial up modems were prevalent, I remember countless times having to call SNET or ATT to reset my modem, mainly because I was never very tech savvy to be able to do it on my own. I would call in; a tech that had a thick accent and said his name was George would start spitting out directions as if I had the same computer science degree he had. Holding the phone in one hand, typing with one finger of the other and trying to understand and implement the techs commands was trying at best. At the end of the ordeal my modem was working but I had no idea what I just did.

As a home inspector, we have the same potential to convey a lot of information during the performance of our job to our clients who may know very little. The information we have accumulated over the years becomes "old hat" to us. My wife says I mumble it in my sleep. But for folks that have never owned or maintained a home before the information conveyed at a home inspection can be a total information overload. Many of my younger clients look like deer in the headlights as we move through an inspection. I am sure they get in the car at the conclusion, look at each other and say "what did he say after hi my name is Stan?" Now I am the tech on the phone.

Since the middle of 2019, a good percentage of my work has been for folks from New York. The above scenario has become abundantly clear even with adults. Apartment dwellers from the concrete jungle buying homes in the suburbs. No supers? What's that green stuff on the ground…oh that's grass. Exaggerated, yes but not by much. So after 30 years of doing home inspections I took a step back and forced myself to see things from the other side, to realize that for some people tightening a door knob is a challenge.

Continued on pg 2

MONTHLY MEETINGS – Details & Info

CAHI's regular monthly meetings are held at the Best Western located at 201 Washington Ave (RT 5), North Haven. Meetings are also broadcast via Zoom. Meetings are still free to members but RESERVATIONS are a MUST. Reservations can be made at our CAHI website.

Most meetings are on the fourth Wednesday of the month from 7-9pm. Guests are always welcome! Guests may attend 2 free monthly meetings to experience our presentations, meet our members, and receive a CE attendance certificate.

Joining CAHI may be done at anytime of the year through our Membership Page.

INSIDE THIS ISSUE

Meeting Dates!

Meetings have Resumed!

November 18th
Report Writing

December
Holiday Catch Up on Credits
Extravaganza
TBA

Presidents Message Continued:

I am coming up on 32 years in this profession. Honestly, I'm not doing many inspections for clients older than me. So I have begun feeling like a father figure lately. I have changed my approach during a home inspection and have become more "teacher" like than "preacher" like. My clients love it, the Realtors eat it up and I feel a sense of fulfillment. I have even stripped down my report so that the pertinent information is easily found, understood and extracted.

There are several inspectors in this organization who remember that back in the day the home inspection was a much simpler and streamlined process. Reports were short and to the point and covered what we were there for, documenting the CONDITION of the home. It was not an encyclopedia (a book or set of books giving information on many subjects or on many aspects of one subject and typically arranged alphabetically) of maintenance, diagrams and web addresses. This additional information while potentially helpful can also muddy the waters.

Try to see things from the other side, at work, during a friendly discussion or even a heated argument. Whether it is a Real Estate agent, your children, or sometimes your toughest adversary, your spouse! Maybe you can be a slightly better home inspector, husband or wife, father or friend. Maybe we can have a little more peace in the world.

This month we will be celebrating Thanksgiving. It will be an interesting one to say the least. Let's make the best of it, but without letting our guard down. We are not out of the woods yet. Zoom family and friends that you usually celebrate with but will not be with this year. Drop a specialty dish off at a neighbor's house that may not have anyone to celebrate with. Even in uncertain times, there is always something to be Thankful for! On behalf of the board let me wish you and your families the best Thanksgiving this year can offer.

Go forth and prosper!

Stan

Weakness on both sides is, as we know, the motto of all quarrels.

Voltaire

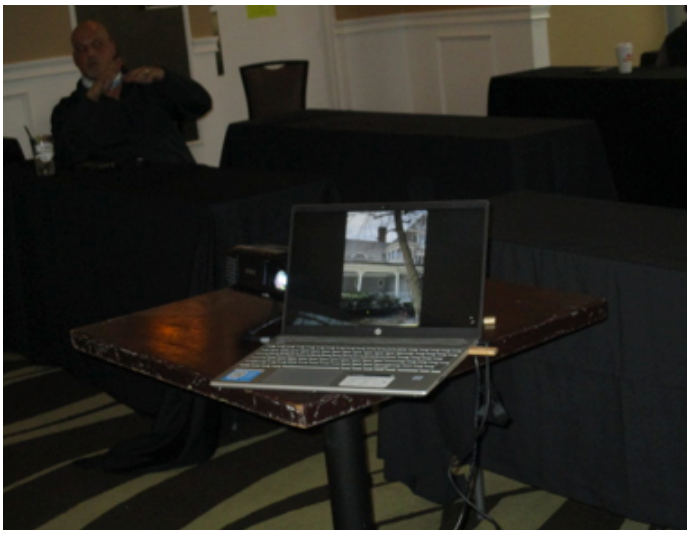
CAHI October Meeting a Success

The future of CAHI monthly continuing education meetings is NOW. October meeting was a split event. Fourteen members attended in person at our old stomping ground. Via Zoom, 38 additional members attended and earned CEU credits toward relicensing. November and the future will be more of the same. Now is the time to talk with nonmembers who have not joined due to travel concerns. They can join now and benefit without the travel time.

Presenter was Hans Vanderhausen

Mr. Education watching at an angle

Disciplined members "social distancing"



Link to the mass of membership

*Connecticut LLC Taxes

How to form an LLC in Connecticut
This Quick Start Guide is a brief overview of how to form an LLC in Connecticut. Click HERE

Detailed Lessons:

1. **LLC Name Search**
2. **Registered Agent**
3. **Certificate of Organization**
4. **Operating Agreement**
5. **EIN Number**
6. **Annual Report**
7. **Business Licenses and Permits**
8. ***Taxes** *(you are here)*

Connecticut LLC costs:
Connecticut state fee: $120 (one-time fee)
Annual report: $80 (every year)

Need help?
Hire a company to form your Connecticut LLC:
Northwest ($39 + state fee) or LegalZoom ($149 + state fee)

* ***Check out*** Northwest vs LegalZoom

Note: Our tax lesson is not as step-by-step as our LLC formation lessons, due to the uniqueness and variation among businesses. Taxes are usually not as straightforward as forming an LLC, and therefore, the information below is an overview, and not a comprehensive guide.

You will likely need to consult with a local tax professional to make sure you meet all your Connecticut tax obligations. We recommend using Thumbtack.

CT Department of Revenue State Tax ID Number

Because you are operating a business in Connecticut, you will need to register with the Department of Revenue and get a CT State Tax Identification Number.

You can register with the Department of Revenue using Form REG-1 (instructions) or register online.

You can contact the Department of Revenue with any questions at 860-297-5962, or visit their contact page for additional information.

Connecticut Business Entity Tax *(no longer exists)*

LLCs doing business in Connecticut used to have to pay a Business Entity Tax (BET). The tax was $250 and was due every 2 years.

However, because the Governor signed Public Act 19-117, the Business Entity Tax (BET) no longer exists.

Any Connecticut LLCs (and out-of-state LLCs doing business in Connecticut) don't have to pay a Business Entity Tax (BET) anymore.

More information is available here: CT Department of Revenue: Connecticut Business Entity Tax Sunset.

Connecticut Sales and Use Tax

Sales and use taxes are due if you sell goods or taxable services in Connecticut.

You also need to obtain a Sales Tax Permit before you begin selling your goods or services.

You are responsible for collecting and paying sales and use taxes whether or not you collect them from your customers. If you do not obtain a Sales Tax Permit, the state will fine you up to $500 and you could possibly face imprisonment.

Connecticut Withholding Tax *(if you have employees)*

As mentioned here, if you're doing business in CT and considered an employer, you must withhold Connecticut Income Tax.

You must first register for withholding tax through the CT Department of Revenue.

Then, you can file your return by mail or you can file online through the Taxpayer Service Center (TCS).

Additionally, you'll need to register with the Connecticut Department of Labor for unemployment and workers compensation taxes.

What other taxes/forms are due?

Depending on your industry, where your business is located, how you are taxed by the IRS, and whether or not you have employees, will determine which additional taxes and forms are due.

Some examples of other taxes and forms due are:

- Form CT-1040
- Form CT-1065
- Form CT-1065 & CT-1120SI (for LLC taxed as S-Corp)
- Corporation Business Tax
- Net Income Tax
- The Minimum Tax
- Surtax
- Estimated Corporation Business Tax
- Controlling Interest Transfer Tax

- Motor Vehicle Fuels Tax
- Franchise Tax
- Property Tax
- And potentially more

Our Recommendation

Calculating your tax obligations in Connecticut can be complicated and if done improperly can negatively impact your LLC.

We recommend that you get help from a tax professional once your LLC is formed. You can use Thumbtack or Yelp.

Hiring a tax professional will not only help you keep your Connecticut LLC in compliance, but it will also give you an advisor to go to for other business questions.

You'll want someone who's a good fit for your company, makes you feel comfortable, and is willing to answer all of your questions. It should be someone you like personally as well as professionally. We recommend talking with at least 2-3 people before making your final decision.

References
http://www.ct.gov/drs/site/default.asp
http://www.ct.gov/drs/lib/drs/publications/pubsip/2015/ip_2015(11).pdf
http://www.ct.gov/drs/cwp/view.asp?a=1454&q=506078

Matt Horwitz

Founder & Educator, LLC University®

To see and activate all links in this article , click HERE for the online version.

2021 Deck Code Highlights

by Glenn Mathewson

The 2021 edition of the International Residential Code is officially complete and ready for printing. Even though many building authorities are only now adopting the 2018 IRC as the local standard, the new prescriptive design provisions contained in the 2021 IRC can be approved by building authorities and used as soon as published. Here's a look at its main provisions.

Table Updates

The pre-engineered design tables have been completely overhauled in a number of ways. For example, all of the structural components in a deck can now be prescriptively sized for more than just a 40-psf live load, with the addition of 50-, 60-, and 70-psf snow loads in all of the design tables.

Tributary area. Previously, for sizing footings, the smallest tributary area of deck listed was 20 square feet, so something as small as a stair landing needed a minimum 14-inch-diameter footing for each corner post. Now, Table R507.3.1 has been expanded to provide a smaller, 5-square-foot area to size from, bringing the minimum diameter down to as small as 8 inches.

Post sizing. Table R507.4 was greatly expanded. Previously, it did not consider any load or post species, so a 4x4 post was limited to an 8-foot height. Now allowing for variables such as snow load, species, and tributary area of deck supported, the table can more accurately size support posts. The common 4x4 post can now, under certain circumstances, extend as high as 14 feet.

Beam design. Table R507.5 was modified to include single-ply beams in all listed species, including redwood and cedar. Single-ply beams are useful for lighter loads and shorter spans, and they eliminate the potential for decay caused by water trapped between two or more beam plies.

Joist span. Table R507.6 was reorganized completely to better present the variables of joist span and joist cantilever. In addition, the "one-fourth-the-backspan" rule for joist cantilevers has been replaced with a maximum allowable cantilever for each common joist span. This change provides for more flexibility in design and more accuracy in the minimum sizes and spans.

Guards

For decades, guards and handrails have been combined together in the specifications for minimum load resistance, though each one supports people in different ways. The minimum live load table, R301.5, now separates these features, primarily so the loading direction of guards can be independently evaluated. While graspable stair handrails are meant to support us and must resist forces in all directions, guards that wrap around a deck are only meant to keep us from falling outward off the edge. Until the 2021 IRC, guards have had to resist 500-lb. loads "in all directions," which has resulted in some robust connection details that wouldn't be necessary for an inward load. Under the 2021 IRC, guards will no longer be required to resist forces pulling inward or upward.

The 2021 IRC will be the first I-code to provide any guidance on guard construction other than the load target and the geometry.

The 2021 IRC will be the first I-code to provide any guidance on guard construction other than the load target and the geometry. Though guards function foremost as a safety feature, they are also an architectural feature, and the market for deck guard design is enormous. This makes prescriptive guard design a difficult and controversial subject.

Nevertheless, the new code specifically prohibits notched 4x4 guard posts, which historically have been attached to rim joists or beams with anything from lag screws to nails and with little validation of their performance beyond a small shove soon after construction. Time and tragedy have taught us that these guards don't work, so the first step towards prescriptive design is prohibiting the notching of 4x4 guard posts at the connection point. In addition, code now requires that the connection extend back into the framing in some manner to help prevent a guard from pulling a rim joist off the ends of the joists or from rotating a single side joist. ❖

Glenn Mathewson is a consultant and educator with Building CodeCollege.com and a frequent presenter at JLC Live.

Stay Safe from Scammers: Tips from the Better Business Bureau

Are you purchasing more online now? It's convenient. It's fast. But is it safe?

The Better Business Bureau (BBB) found that online purchase scams have been in the top three types of scams since 2017. With this year's social distancing to limit exposure, and many businesses previously closed and now slowly reopening with limited hours, many consumers are turning to online purchases for home delivery. But predators have been taking advantage of this increase in online purchases.

BBB reports that in 2020 so far, 64% of reported scams are from online purchases, with a staggering 80.5% of consumers reporting they lost money from these scams.

What is an Online Purchase Scam?

Online purchase scams typically involve the purchase of products and/or services via a website. Scammers offer attractive deals, but no product/service is delivered once payment is made. Or scammers pretend to purchase an item, but then send a fake check and ask for a refund of the "accidental" overpayment.

Outsmart Scammers with Prevention Tips

BBB offers helpful information and tips to stay safe from online purchase scams and many other types of scams, such as scams for rental, employment, credit card and debt relief, tax collection, health care, and identity theft.

Ten Tips to Protect Against Most Scams

1. Never send money via gift card or wire transfer to someone you have never met face-to-face.
2. Avoid clicking on links or opening attachments in unsolicited emails.
3. Don't believe everything you see.
4. Double check your online purchase is secure before checking out.
5. Use extreme caution when dealing with anyone you've met online.
6. Never share personally identifiable information with someone who has contacted you unsolicited, whether it's over the phone, by email, on social media, even at your front door.
7. Resist the pressure to act immediately.
8. Use secure and traceable transactions.
9. Whenever possible, work with local businesses.
10. Be cautious about what you share on social media.

Find More Tips at the Better Business Bureau

BBB offers a handy scam tracker to find local scams in your area, a way to file a complaint, and a weekly scam alert email to stay updated on scammers' latest tricks and tips to stay ahead of them.

Safeguard your health. Safeguard your family. And safeguard against scammers.

Author

Kiran Dhillon

An insatiably curious storyteller, Kiran is the communications lead for the Multi-Channel Technology Directorate with VA's Veterans Experience Office. Kiran joined the Department of Veterans Affairs by way of the Department of Defense and the U.S. Peace Corps.

BY STEVE EASLEY

Continuous Insulation: Problems and Solutions

If you've watched the evolution of energy codes over the past couple of decades, you've probably noticed an increasing emphasis on exterior insulation for walls. As early as 2006, the International Energy Conservation Code (IECC) specifically referenced exterior insulation as an option in its insulation tables. By 2012, the prescriptive insulation requirements had mandated only continuous insulation options for climate zones 6, 7, and 8. The upcoming 2021 IECC, which recently passed, will allow a "fat" (R-30) cavity insulation option for zones 6, 7, and 8, but it has stepped up requirements in climate zones 4 and 5, where all insulation options require some continuous insulation.

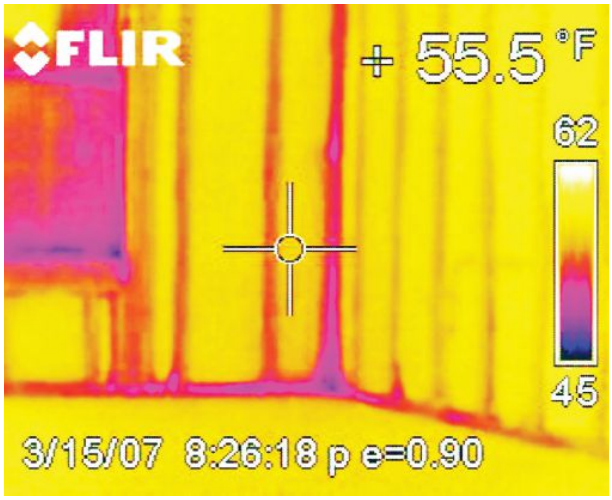
Continuous exterior insulation has advantages. First of all, it substantially increases the true R-value of walls at a fairly low cost. For example, adding one inch of R-5 exterior insulation raises the real (whole wall) R-value of a 2x4 wall with R-13 cavity insulation from just R-10.7 to R-16. Second, most homes have framing factors of 25% (meaning that the true R-value of 25% of the windowless walls is the R-value of the wood, or R-3.5). Exterior insulation reduces thermal bridging across the wall through framing members, and it keeps the sheathing warmer (which reduces the risk of condensation and mold growth on the sheathing).

The practice of applying foam insulation to wall exteriors can be complicated, however, and it comes with some drawbacks. In particular, plastic foam is vapor impermeable, which means walls can't dry to the outside if they do get wet. To avoid callbacks, you have to address water and moisture management with greater diligence when you make the move to exterior foam insulation. And you may have to rethink the way you attach and flash your windows.

THE ADVANCING CODE

In the prescriptive tables of the upcoming 2021 IECC, a combination of cavity insulation with exterior insulation is strongly favored. In climate zones 6, 7, and 8, you can have either R-30 in the wall cavity, or a combination of R-20 cavity insulation with R-5 exterior insulation (R-20+5), or a combination of R-13 cavity insulation and R-10 exterior insulation (R-13+10). In climate zones 4 and 5, continuous exterior insulation will be the only option: R-20+5 or R-13+10. In climate zone 3, you can choose among R-20 in the cavity, R-13+5, or R-0+15. And in climate zones 1 and 2, you can choose between R-13 in the cavity or R-0+10.

Extruded polystyrene foam is rated at R-5 per inch and polyiso at R-6.5 per inch. So depending on the options they choose, builders may need to apply an inch, 2 inches, or sometimes even



Photos by Steve Easley

An over-framed wall like this (above left) is a good candidate for exterior foam insulation. The infrared image (above right) shows the cold studs in a heated house on a winter day. Exterior foam insulation could prevent this source of heat loss.

Studs conducting heat (above left) stand out on a frosty morning. Exterior insulation would eliminate this heat loss. Air-sealing is critical when walls are vapor-closed to the outside. Here, a builder has correctly air-sealed a bottom wall plate (above right).

3 inches of foam. The energy benefit aside, there are practical problems to applying that much foam to a building exterior.

MOISTURE RISKS

In the 1980s, we built a demonstration home at Purdue University that had heating and cooling costs of less than $200 a year. Part of how we accomplished that was by sheathing the exterior of the building with polystyrene. At that time, structural codes allowed us to install wood structural panel sheathing only at the building corners. But modern wall bracing codes in most regions require more extensive use of structural panels, and using continuous structural wood panel sheathing is the best way to get a rigid building. Even though I believe installing exterior insulation is key to getting a high-performing building, there's an increased level of risk when you cover a hygroscopic material like OSB sheathing with an impermeable material like rigid polystyrene foam. To forestall this risk, follow good moisture management principles and inspect everything before cladding is installed.

Moisture problems come from two places—they come from inside the home, or from outside. Interior moisture is the trickiest. Most air has moisture in it, and when moisture-laden air comes in contact with a cold surface, the moisture condenses out and dampens the surface. But if the sheathing has an impermeable layer of foam over it, the building can't dry so well to the outside.

To avoid problems, you need to pay close attention to three things: First, you need to air-seal before the insulation is installed. Most of the moisture that enters the wall cavity from the interior is driven by air currents. Second, don't install vinyl wallpaper on interior wall surfaces. Since the wall can't dry to the outside, you have to give the wall a chance to dry to the inside. Third, you need to reduce the indoor moisture load with ventilation. If enough moisture condenses on the sheathing to raise the surface relative humidity in the 70%-to-80% range, mold can start growing. Effective spot ventilation—good bathroom and kitchen exhaust fans—will go a long way towards reducing indoor moisture levels. Ideally, you should install technology that can automatically sense and control humidity.

The good news is that because exterior insulation is outboard of the sheathing, that sheathing stays warmer. Warmer sheathing surface temperatures mean lower surface relative humidity, so the sheathing is less likely to dampen to the point that it reaches the threshold for mold growth. Even so, when you apply impermeable foam insulation to the outside of a building, you need to be fastidious about air-sealing before the insulation is installed so that air currents across the wall are minimized. In addition, it's critical that the home is watertight before the cladding is installed.

One option is to install the foam board first, then sheathe over it. That lets the sheathing dry to the outside. But if you build in a location where higher levels of wall bracing or shear walls are required, you'll want to check with an engineer to make sure that the shear capacity of your sheathing is adequate. When sheathing is held away from the studs by insulation, its ability to resist racking forces is reduced.

THE WINDOW INSTALLATION PUZZLE

Controlling indoor humidity and building an airtight enclosure reduces the moisture risk from inside the home. That leaves the risk from outside the home—which is primarily found at penetrations like windows, doors, and roof-wall intersections. Most builders have plenty of experience installing windows in a wood-frame

Sheathing can be applied outboard of the foam (above left). This lets the sheathing dry to the outside. ThermalBuck (above right), an insulated window mounting system, creates a positive attachment for the window while limiting thermal bridging.

wall without exterior insulation. But many builders may not have a usual method for installing windows when the wall has been packed out with an inch or two of extruded polystyrene.

And while the code may require exterior insulation, the code doesn't tell you how to fasten and flash the windows into a foam-insulated wall. However, there is a resource for this: a document called FMA/AAMA/WDMA 500-16, which goes by the title "Standard Practice for the Installation of Mounting Flange Windows into Walls Utilizing Foam Plastic Insulating Sheathing (FPIS) with a Separate Water-Resistive Barrier." In addition to following the guidance in this document, you should cross-check the window, housewrap, and flashing manufacturers' guidelines for their products. If there's a conflict, code will defer to the window manufacturer's instructions.

A lot of testing and thought went into the creation of FMA/AAMA/WDMA 500-16. Recognizing that the sequencing of the trades varies from builder to builder, the standard practice offers multiple alternatives for how to install the windows. In one method, housewrap is applied to the building before the window bucks and foam are attached; in another, the housewrap goes on after the bucks and the insulation. In a third method, the window is applied directly to the wall with no bucks. In every case, the flashing and housewrap are designed to direct water down and out of the wall assembly.

Method A. In one version of Method A from the standard practice, the foam is applied directly to the sheathing and the housewrap is applied over the foam. The window buck (termed a "Rough Opening Extension Support Element," or "ROESE," by the document) goes on the wall first. The full sequence is as follows: window buck; insulating foam; housewrap (WRB); sill flashing; window; jamb flashing; head flashing; head tape.

In another version of Method A, the housewrap is applied after the window is installed. In this version, the sequence is: window buck; insulating foam; skirt; sill flashing; window; jamb flashing; head flashing; housewrap (WRB); jamb tape; head tape.

If you are concerned about thermal bridging at the window buck, consider a prefabricated rigid-foam product that is designed to take the place of the wood buck, such as the one shown above.

In Method B, the window is installed into the window buck over the housewrap, and the foam insulation is applied next. This method uses either fluid-applied or peel-and-stick flashing.

Method C takes a different approach, applying the housewrap and the window to the wall before the foam is applied. In this case, there's no window buck.

For added security, I recommend that builders consider a rainscreen wall assembly. With a rainscreen, water striking the cladding has to jump across a 1/4- to 3/4-inch gap to reach the weather barrier, and even if that happens, the water just hits the weather barrier and runs down. So rainscreens provide you with exponentially better protection against water getting behind the foam.

Steve Easley is principal of Steve Easley Associates, a company based in Scottsdale, Ariz., that provides building-science consulting, training, and quality assurance for builders nationwide.

Winterizing Your Property

As fall approaches and temperatures start dropping, it's time to work on preparing your property for the rigors of winter. Preparing for the consequences of freezing temperatures, ice accumulation, and snowfall ahead of time will save you energy, money, and stress. According to the Insurance Institute for Business and Home Safety, "Extreme winter weather is the third-largest cause of insured catastrophe losses after hurricanes and tornadoes. Losses from snow, ice, freezing, and related causes averaged $1.2 billion annually over the past 20 years."

Preparing your property for winter is an important task. While much of the work can be considered do-it-yourself, there are inspections or jobs that property owners should consider outsourcing to reputable companies. Here is a comprehensive list of winterizing steps you should take.

Roof:

A thorough inspection of your attic, skylights, and roof can identify any damage that occurred during the warm weather months that may cause issues when ice and snow start to form. A roof in good condition should be able to withstand 20 pounds of snow/ice per square foot. A roof collapse can be very costly. Don't hesitate to call a professional to inspect your roof, as the task can be dangerous.

Pipes:

Some pipes are at a higher risk for freezing during winter months, such as those on the exterior of your home, located in exterior walls, or exposed pipes in unheated areas of the house. To help avoid the freezing of outdoor pipes, follow these tips for preventing freezing pipes.

Pool:

If you have a pool, make sure the pool, skimmer, and filter are cleaned out and follow the manufacturer's guidelines on additional cleaning steps or the addition of winterizing chemicals. Drain the pool to a level below the skimmer mouth, but do not empty the pool.

Yard/Outdoor Maintenance:

The weight of snow and ice can cause tree limbs to break and damage your property, or the property of neighbors, so make sure to trim them. Removing any additional debris, sealing the deck, and draining any water fixtures are good preventative tasks. Here are some other tips for preparing your home for winter.

Gutters:

During your outside maintenance, make sure you prioritize your gutters. Gutters should be cleaned out in the fall and then again before winter temperatures start in your area to make sure that water can drain appropriately.

Windows:

While technically inside your home, windows are worth putting on both the home and property preparation list as they can be a significant player in heating your house. Inspect all of your windows and consider replacing inefficient or very old windows with new, more energy-efficient windows. Also, check caulking to make sure no hot air is escaping.

Doors:

Just as you want your windows to keep hot air in and the cold weather out, your doors also serve this purpose. Check on your weather stripping and consider draft guards or even storm doors if your area gets unusually cold.

Irrigation/Sprinkler System for Lawns:

Sprinkler systems should be winterized early in the season, before the first freeze. This maintenance can be done by your sprinkler service or yourself. Turn off the water supply and rid the lines entirely of the water to prevent freezing.

As you are preparing your home and property for winter, make sure you are also ready for other emergencies. Starting with an emergency kit, downloading some apps to help you in an emergency, and talking to your insurance representative to verify your coverage. Don't get caught unprepared, take the time today.

Adobe Stock Images

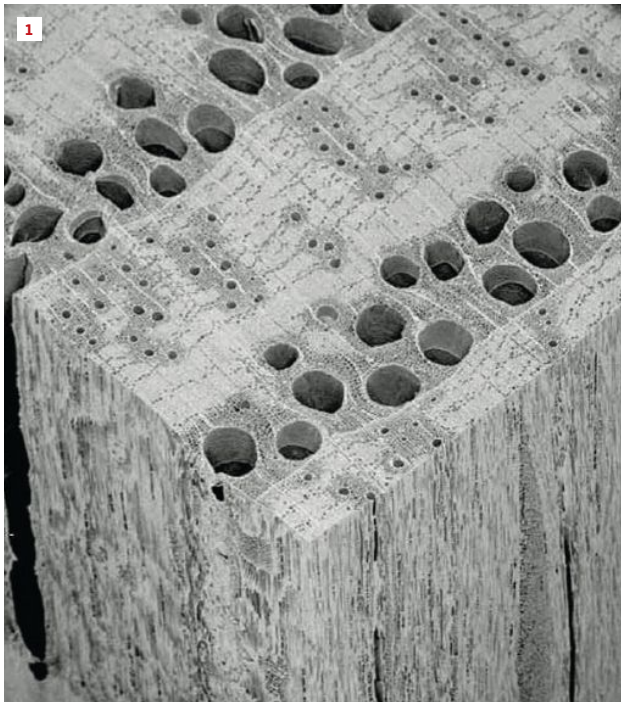
Wood Basics

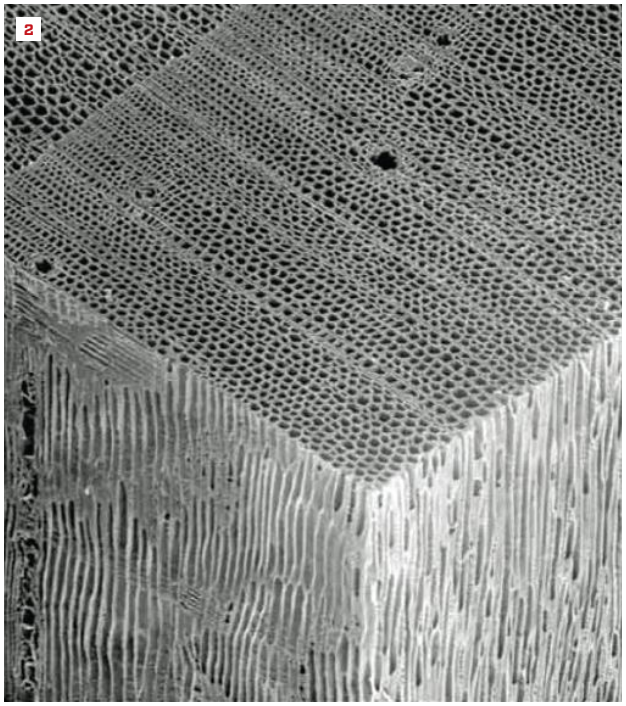
A primer of how wood works

BY JLC STAFF

Editor's note: The single best resource every carpenter should consult to understand wood is the Wood Handbook, *published by the U.S. Department of Agriculture Forest Products Laboratory (available free online). The current edition is all of 590 pages. The article here is intended as an introduction to the basic properties of wood, and only begins to scratch the surface of the engineering and material-science knowledge in the* Wood Handbook. *Our goal with this overview is to give you a footing on which to explore this extraordinary but hefty resource. Part 2 in this series (to come) will go into greater detail about the dimensional stability of woods. Part 3 will go into detail about the mechanical properties, primarily the strength, of wood.*

Early builders learned by trial and error which wood species to use and which wood from trees grown in certain locations and under certain conditions was stronger, more easily worked—or finer grained—than wood from other locations. White oak, for example, is tough, strong, and durable, which made it a prized choice for shipbuilding, bridges, barn timbers, fence posts, and flooring. Woods such as black walnut and cherry, on the other hand, were primarily valued as cabinet woods. Hickory was made into tough, resilient tool handles. Black locust was prized for barn timbers and trunnels (or "treenails,"the stout pegs used for joining timber frames). Modern research—much of it performed by the Forest Products Laboratory and through wood





In each photo above, the top of each block sample represents the transverse, or "end," surface. On the white oak sample **(1)** the vessels stand out as the most prominent cells. On the softwood sample **(2)**, the corresponding tracheid cells are much smaller in size but make up the bulk of the wood.

research programs at a handful of universities worldwide—has substantiated that location and growth conditions significantly affect wood properties and has given us the means to understand and predict wood performance.

SOFTWOODS VS. HARDWOODS

The differentiation of softwood and hardwood stems from the difference in two broad classes of trees defined by how they reproduce. The softwoods we use for building in the U.S. come mostly from conifers—the needle-leaved evergreen trees, such as pine, spruce, and fir. In botanical terms these trees are gymnosperms, which produce "naked" seeds in cones. Hardwoods come from angiosperms—flowering trees that produce seeds covered by a protective fruit of some sort (nuts, acorns, and samaras—aka "keys," such as those from maple trees—are all fruits). The hardwood trees used for building are typically broad-leafed, deciduous trees, such as maple, birch, and oak.

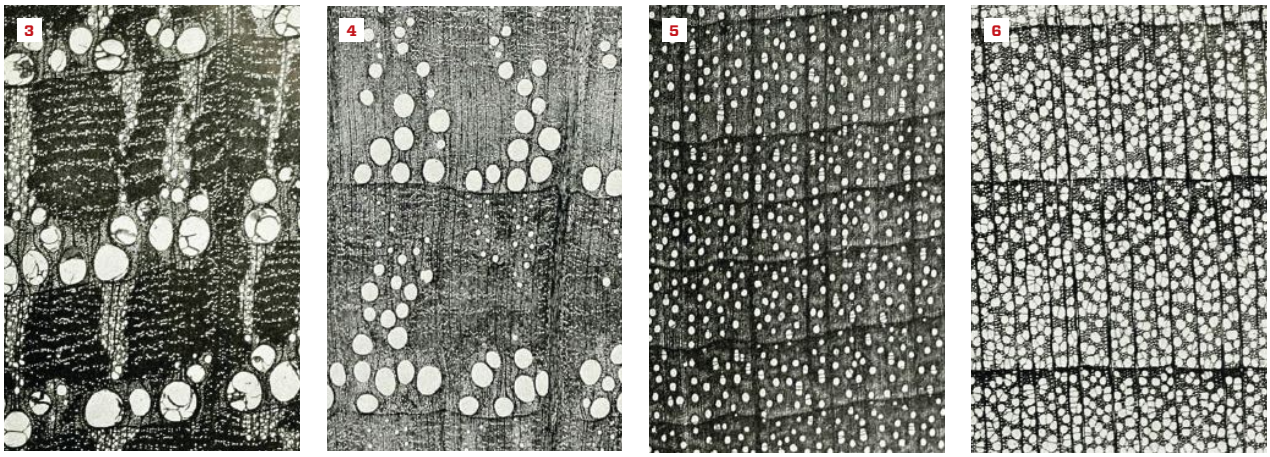
Softwoods and hardwoods have very different component cells (see photos, above). Hardwoods have greater structural complexity with both a greater number of cell types and great variability within the cell types. Softwoods have a simpler, basic structure with only two cell types and relatively little variation in structure within these cell types.

The single most identifiable difference between the two types of wood is that hardwoods have pores (or "vessel elements"). Individual pore cells are separated by perforated plates, and align end-to-end up the trunk. Water is conducted up the trunk of a hardwood tree by passing from pore cell to pore cell, driven through the permeable plates by a combination of the following forces:

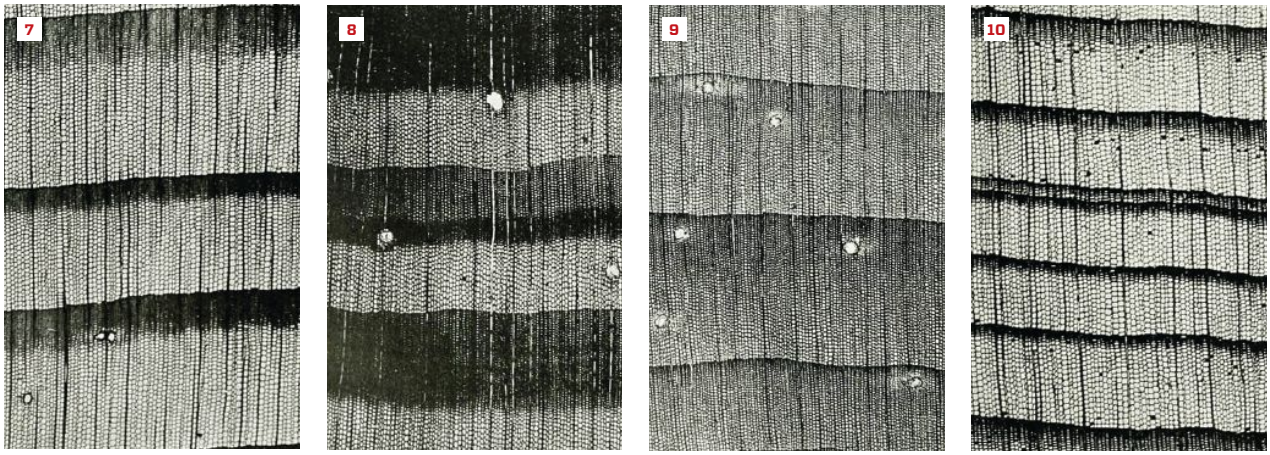
- Osmosis (the movement across a membrane from a high concentration of water to a low concentration) that pushes water up the trunk, beginning in the roots and continuing cell-by-cell, passing up through each pore cell.
- Capillary action within the tubular pores.
- Evaporation pressure, which pulls water up the trunk as water evaporating from the leaves creates suction on each pore cell.

Fibers. The strength of hardwoods comes from fibers—spindle-shaped cells with relatively thick walls and small inner cavities that run vertically around the pores. Wood fiber cells are two to 10 times longer than individual pore cells. The thickness of the fiber cell walls and the mass of fibers surrounding the pores determine the wood's density and strength. Low-density, low-strength hardwoods,

Photos 1-10 courtesy USDA Forest Products Laboratory



Hardwoods (transverse sections). White oak **(3)**; red oak **(4)**; sugar maple—the most common of the maples known as "hard maple" **(5)**; yellow polar **(6)**.



Softwoods (transverse sections). Douglas fir **(7)**; longleaf pine—the most common of the woods known as southern yellow pine **(8)**; white pine **(9)**; redwood **(10)**.

such as cottonwood and basswood, have thin-walled fibers; species with thick-walled fibers include hard maple, black locust, and ipe.

Rays. Fibers are not to be confused with rays. Medullary rays are chains of horizontal cells that extend in bands in a radial direction (perpendicular to the growth rings; in a transverse section, they appear as lines radiating from the center of the trunk). Ray cells in both hardwood and softwood trees serve to store food and distribute it horizontally across the trunk.

Instead of round pores, softwoods have long, rectangular tracheid cells that overlap vertically. These cells serve as both the wood structure and a means to move water. The tracheids have circular "pits" at each end that connect to adjacent tracheids and are covered by a membrane. Water flow up a softwood tree is driven by the three forces described above (osmosis, capillary action, and evaporation pressure), which move water across the pits from tracheid to tracheid in a zigzag fashion through the overlapping tracheids.

Sap vs. resin. Many of the softwoods we use in building also produce resin, which is not the same as sap. All trees produce sap, which is mostly water with dissolved sugars and minerals that serves as the primary nutrient to sustain the tree's growth. Resins,

The sapwood—the lighter ring of wood beneath the bark—is made up of the cells that conduct water (sap) up the trunk. As a tree grows, these cells harden, filling up with deposits of various materials that give the heartwood a darker color and make it stronger and more durable to weathering than sapwood **(11)**.

on the other hand, are secretions from specialized cells within the tree that provide a defense against infection and insects. The resin canals (which are actually voids between cells) are often quite distinct and visible by eye in pines, but they exist in most conifers. (In the photos on the previous page, resin canals are most prominent in the yellow and white pines, but there are a few in the Douglas fir sample, and much smaller but evident in the redwood sample.)

SAPWOOD VS. HEARTWOOD

Sapwood is located next to the bark. It is the active part of a tree that conducts the water (sap) from the roots to the leaves. As a rule, the more vigorously growing trees have wider sapwood layers. Many second-growth trees of salable size consist mostly of sapwood.

Cells in the heartwood, the inner part of the tree, no longer conduct water up the trunk. As a tree grows, the cells harden and fill up with deposits of various materials that frequently give the wood a much darker color. In hardwoods, the pore cells grow tyloses, which appear in the pores like foam. These trap materials (gums and precipitates) and cause the cells to harden, usually making the heartwood stronger and more durable to weathering than sapwood.

Unless treated, all sapwood is susceptible to decay. In some woods, including redwood, western red cedar, and black locust, material deposited in the heartwood makes it heavier and more resistant to crushing than the sapwood.

PHYSICAL PROPERTIES OF WOOD

A spectrum of physical characteristics is available among the many species. Often more than one property is important. For example, when you are selecting an untreated species for a particular use, the wood's texture, grain pattern, or color must be weighed against machinability (does the grain split out when nailed or the surface fuzz up when planed?) and stability (will the wood shrink and warp more than other species for the given use conditions?).

Plainsawn vs. quartersawn lumber. Lumber can be cut from a log in two distinct ways:

- When cut along a tangent to the annual rings, lumber is called "plainsawn" in hardwoods and "flat-grain" or "slash-grain" wood in softwoods.

Photo: Musskiprozz

Wood Moisture Content Varies With Environment Conditions

Temperature (°F)	Relative Humidity (%)								
	10	20	30	40	50	60	70	80	90
	Moisture Content (%)								
30	2.6	4.6	6.3	7.9	9.5	11.3	13.5	16.5	21.0
40	2.6	4.6	6.3	7.9	9.5	11.3	13.5	16.5	21.0
50	2.6	4.6	6.3	7.9	9.5	11.2	13.4	16.4	20.9
60	2.5	4.6	6.2	7.8	9.4	11.1	13.3	16.2	20.7
70	2.5	4.5	6.2	7.7	9.2	11.0	13.1	16.0	20.5
80	2.4	4.4	6.1	7.6	9.1	10.8	12.9	15.7	20.2
90	2.3	4.3	5.9	7.4	8.9	10.5	12.6	15.4	19.8
100	2.3	4.2	5.8	7.2	8.7	10.3	12.3	15.1	19.5

Wood Shrinkage Values

Species	Shrinkage from green to oven-dry moisture content	
	Radial (%)	Tangential (%)
HARDWOODS		
Cherry, black	3.7	7.1
Maple, black	4.8	9.3
Oak, northern red	4.0	8.6
Oak, white	5.6	10.5
SOFTWOODS		
Cedar, northern white	2.2	4.9
Douglas fir, coast	4.8	7.6
Hemlock, western	4.2	7.8
Pine, eastern white	2.1	6.1

Table 1 (above). The moisture content of wood changes as a function of the temperature and relative humidity. For example, if a space is 30°F and 80% relative humidity (for example, in an attic in winter), the wood there will slowly rise to 16.5% moisture content. **Table 2** (right). Shrinkage values of selected woods along the rings (tangential) and across the rings (radial).

■ When cut radially (parallel or near parallel to a radius of the growth rings), lumber is called "quartersawn" or "vertical-grain" wood.

Quartersawn lumber is usually not cut strictly parallel with the rays, and plainsawn boards are often far from being tangent to the rings. In commercial practice, lumber with rings at angles of 45° to 90° with the wide surface is called quartersawn, and lumber with rings at angles of 0° to 45° with the wide surface is called plainsawn.

Moisture content. Sapwood's moisture content is usually higher than heartwood's (though not in all species). Moisture can exist in wood as a liquid or vapor within cell cavities or as water bound chemically within cell walls. The moisture content at which cell walls are saturated (with "bound" water when no water exists in cell cavities) is called the "fiber-saturation point." This averages about 30% moisture content for all species.

The moisture content of wood below the fiber-saturation point is a function of both the relative humidity and the temperature of the surrounding air. The relationship between equilibrium moisture content, relative humidity, and temperature is shown in Table 1 (above).

Wood in buildings is almost always undergoing at least slight changes in moisture content as the temperature and relative humidity of the surrounding air change. These changes usually are gradual. Short-term fluctuations tend to affect only the wood surface. Protective coatings such as varnish, lacquer, or paint will slow down the moisture content changes but will not stop them entirely. The general goal in seasoning and storing wood is to bring the wood near the moisture content that it will typically have in service. The protective finish then helps to slow down the changes and keep the moisture content within a more stable range over its service life.

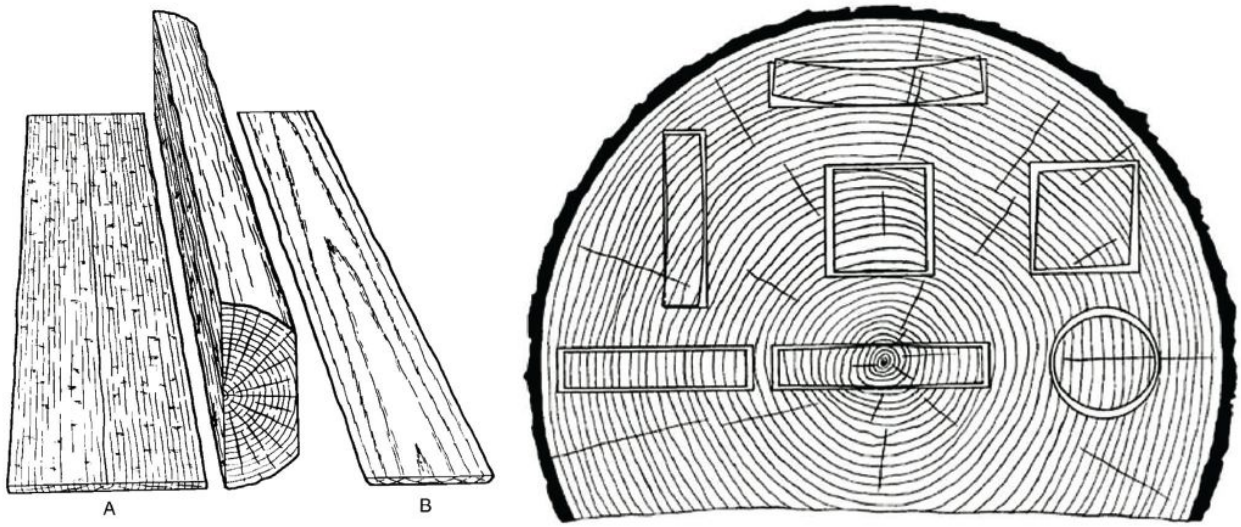
Shrinkage. Wood is dimensionally stable above the fiber-saturation point. But below that point, it shrinks when losing moisture and swells when gaining moisture. This shrinking and swelling may result in warping, checking, splitting, or other performance problems.

Wood shrinks most in the direction of the annual growth rings (tangentially), about one-half as much across the rings (radially), and only slightly along the grain (longitudinally). The combined effects of radial and tangential shrinkage can distort the shape of wood pieces. The illustration on the following page shows the distortion that is most likely in boards, depending on where they are cut from the tree.

Wood shrinkage is affected by a number of variables. In general, greater shrinkage is associated with greater density. The size and shape of a piece of wood may also affect shrinkage. So may the temperature and rate of drying for some species. Radial and tangential shrinkage for a few common species are shown in Table 2 (above).

Longitudinal shrinkage. Longitudinal shrinkage (along the grain) is generally quite small—between 0.1% and 0.2% for most species of wood.

Certain abnormal types of wood, however, exhibit excessive longitudinal shrinkage. "Reaction wood," whether it is



Above at left, quartersawn, or vertical-grain, lumber (A), cut radially (or near radially) to the rings, is sometimes preferred for its straightness, but plainsawn, or flat-grain, lumber (B) has more interesting grain patterns. At right, wood shrinks most in the direction of the annual growth rings (tangentially), about one-half as much across the rings (radially), and only slightly along the grain (longitudinally). The combined effects of radial and tangential shrinkage can distort the shape of wood pieces. The illustration shows the distortion that is most likely in boards, depending on where they are cut from the tree.

compression wood in softwoods or tension wood in hardwoods, tends to shrink excessively along the grain.

WORKING QUALITIES OF WOOD

The ease of working wood with hand tools generally varies directly with the specific gravity (density) of the wood. The lower the density, the easier it is to cut. A species that is easy to cut, however, does not necessarily develop a smooth surface when it is machined.

Three major factors other than density may affect the production of smooth surfaces during machining:

- Interlocked and variable grain. Interlocked grain is characteristic of tropical species. It can cause difficulty in planing quartered surfaces unless attention is paid to feed rate, cutting angles, and the sharpness of knives.
- Hard mineral deposits. Hard deposits, such as calcium carbonate and silica, can dull all cutting edges. This is worse when the wood is dried before milling.
- Reaction wood. Tension wood in hardwoods, especially, can cause fibrous and fuzzy surfaces and can pinch saws due to stress relief. The pinching may result in burning and dulling of the saw teeth.

WEATHERING

The color of wood is soon affected when exposed to weather. With continued exposure, all woods turn gray. This thin, gray layer is composed chiefly of partially degraded cellulose fibers and microorganisms. Further weathering causes fibers to be lost from the surface, but the process is so slow that only about one-quarter inch is lost in a century.

The chemical degradation of wood is affected greatly by the wavelength of light. The most severe effects are produced by ultraviolet light. As wetting and drying take place, most woods develop physical changes, such as checks or cracks. Low-density woods acquire fewer checks than do high-density woods. Vertical-grain boards check less than flat-grain boards.

Boards tend to warp (particularly cup) and pull out their fastenings. The greater the density and the greater the width in proportion to the thickness, the greater is the tendency to cup. Warping also is more pronounced in flat-grain boards than in vertical-grain boards. For best cup resistance, the width of a board should not exceed eight times its thickness.

Biological attack of a wood surface also contributes to color changes. When weathered wood has a dark gray and blotchy appearance, it is due to dark-colored fungal spores and mycelium on the wood surface. The silvery gray sheen often sought on weathered wood occurs most frequently where microorganism growth is inhibited by a hot, arid climate or salt air.

The contact of fasteners and other metallic products with the weathering wood surface is another source of often undesirable color.

Illustrations courtesy USDA Forest Products Laboratory

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The public is always welcome.

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