EXTERIOR WOOD DOORS
AND THE BATTLE AGAINST MOISTURE

AN AIA/CES REGISTERED COURSE
FROM SIMPSON DOOR COMPANY

Simpson® Door Company

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Learning Objectives

After completing this course, participants will be able to:

1. Specify how wood doors can be incorporated into a range of architectural styles for homes and light construction

1. List the key components of stile and rail wood doors

2. Describe common points of moisture vulnerability in exterior wood doors

3. Explain manufacturing materials and techniques that can protect wood doors against water infiltration

4. Discuss methods for designing building overhangs, and selection of wood finishes, that further enhance wood door weatherability

Use of Wood Doors in Architectural Designs

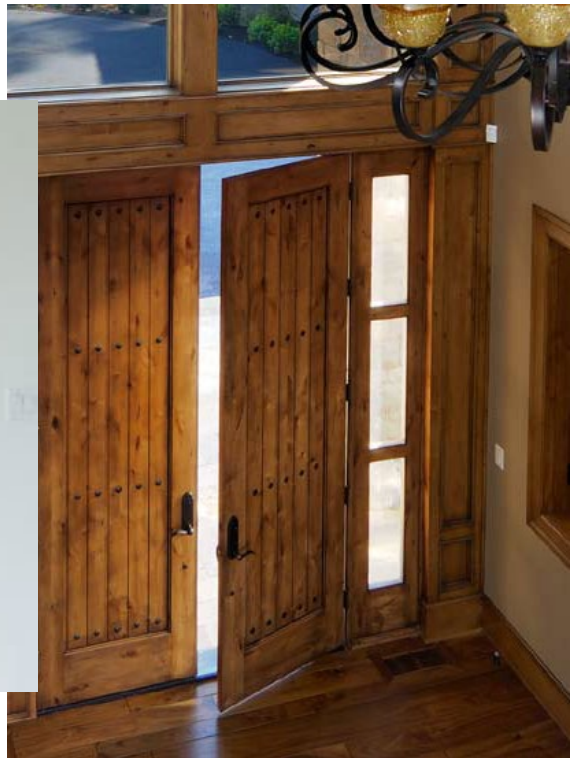
Aesthetic & Performance Attributes of Wood Doors

Exterior wood doors hold universal appeal for the numerous advantages they offer in residential and light commercial applications. Beauty, design flexibility, ease-of-use, and natural insulating and sustainable attributes make handcrafted stile and rail wood doors a smart and stylish option for creating attractive and inviting entryways.

- Unmatched beauty and warmth
- Many styles, species and finishing options
- Doors can be made to a specific height and thickness
- Wide range of design choices
- Wood is a natural, replenishable material
- Insulating properties – both temperature and sound

Unmatched Beauty & Warmth

Wood has been used for thousands of years as a building material due to its pleasing aesthetics and tangible connection to nature. For many architects and designers, the variety of warm, rich hues, depth, detail and texture that wood can add to a space is unattainable with any other material.



Unmatched Beauty & Warmth

As humans, we may be instinctively more drawn to wood than other materials…

Biophilia – A hypothesis introduced by German psychologist Erich Fromm, and popularized by American biologist Edward Wilson, suggests there is an inherent connection between humans and other living things. The word “Biophilia” means “love of life or living systems.”

Many Style, Species and Finishing Options

There are dozens of wood species that can be used to make a door, each of which offer their own unique design, color and characteristics. Some are light in color with fine lines like poplar and white pine, while others are darker like cherry and mahogany. Further, some have knots or more dramatic grain patterns that add visual interest such as knotty alder, knotty pine, hickory or black locust.

Wood doors can be stained, painted or have a simple clear-coat finish applied to match any room, style, or design. Their workability and versatility allow architects and designers to get exactly what they are looking for in an interior or exterior door.

Wood Species

There are many different wood species that can be used to make doors. The following are some of the most commonly used soft and hardwoods (these can vary depending on geographical location).

Softwoods

Douglas Fir – Is popular for its vertical grain and warm coloring, ranging from yellowish-tan to light brown.

Western Hemlock – Has a lighter, creamier color and can accept a variety of stains. Its straight grain and consistent, even texture are favored for all manner of construction, as well as veneer.

Wood Species

Softwoods (continued)

Ponderosa Pine – Can be clear or knotty and is honey-colored with a straight and relatively fine grain. Its depth and warmth bring a feeling of comfort and relaxation to a space.

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Nootka Cypress – Also known as Alaskan Yellow Cedar, Nootka Cypress is a durable wood with excellent stability. It offers a fine texture with uniform color and straight grain.

Wood Species

Hardwoods

Red Oak - Can vary slightly in color, but typically is reddish-brown. It has a straight grain, medium to coarse texture and is medium to heavy in weight.

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Cherry - A temperate hardwood with a wavy or straight grain and fine, even texture. It is medium reddish brown in color and darkens over time.

Wood Species

Hardwoods (continued)

Maple - Pale and near white in color, darkens toward the heart and has distinct red-brown latewood lines. Maple has a distinctive figure and is hard, strong and heavy.

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Knotty Alder – Is light brown in color with yellow and peach hues. The knots in Knotty Alder give it a rustic, more informal presence, and vary in size and distribution.

Wood Species

Hardwoods (continued)

Walnut – Recognizable for its chocolate-brown coloring and straight to wavy grain, walnut is an American-classic that is reflective of colonial style homes and architecture.

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Sapele Mahogany – Is a reddish-brown tropical hardwood with a fairly straight, tight grain. Its distinctive ribbon-like pattern and varied color make for any eye-catching door.

Wood Species

Hardwoods (continued)

Hickory – One of the heaviest and hardest woods in North America, hickory is highly rot-resistant, even in extreme conditions. Its grain pattern is similar to oak, but with more color variation between growth rings.

Bamboo – Bamboo is a grass, not a hardwood, but is comparable to hardwoods for similar hardness characteristics. It has become very popular in recent years for its durability and rapidly renewable properties. It has a warm, rich hue that complements a wide-range of architectural styles, from modern to retro.

Wide Range Of Design Choices

Wood is easy to work with and extremely adaptable. It can be easily shaped, sanded, stained, painted, repaired, replaced or altered. Thus, wood doors can be ordered in a variety of sizes, shapes and designs, and with a wide range of glass options to fit with any architectural style – from Colonial to Craftsman to modern. And unlike alternative materials, wood doors can be safely altered in size in the field, if necessary.

Wide Range Of Design Choices

Some wood door manufacturers have the technology to take sketches and general descriptions and turn them into reality. Based off of the design concept provided, craftsmen can translate it into a one-of-a-kind door, allowing for limitless design options.

Wood is a Natural, Replenishable Material

Renewable, recyclable natural resource

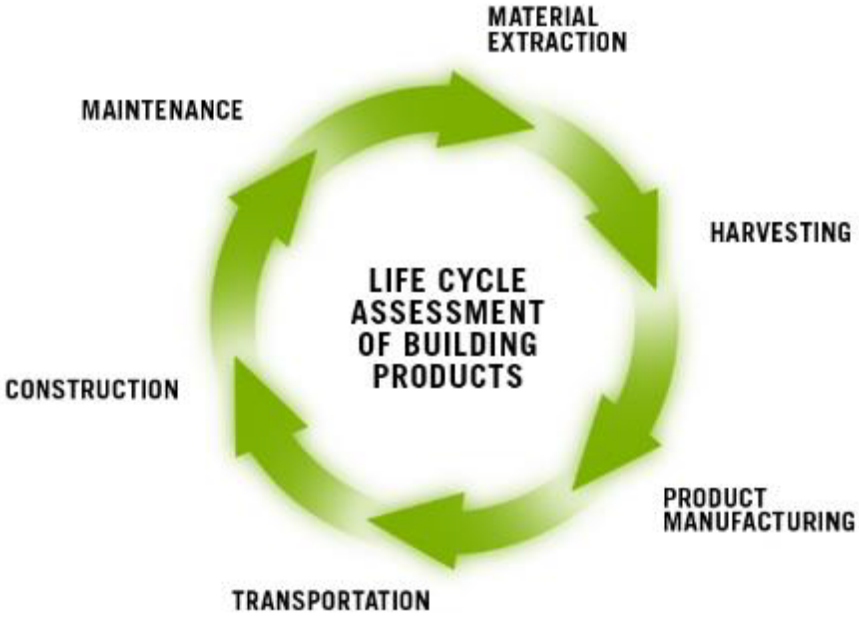
Wood is one of the only major building materials that is renewable. It is abundant and readily available, and sustainable forestry practices help ensure replanting exceeds harvesting. Wood can be recovered and reused in other projects or in the manufacture of other products.

Annual forest growth has exceeded harvest since the 1940s and the U.S. today has nearly the same amount of forestland as it did in 1920 – According to the American Forest and Paper Association and Clemson University

Wood is a Natural, Replenishable Material

Lifecycle analysis

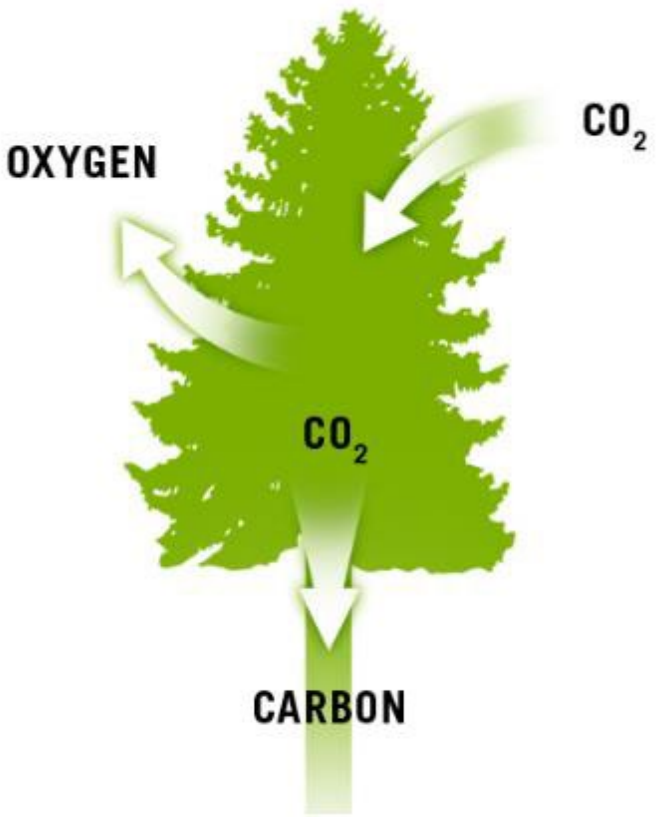
Lifecycle assessment (LCA) studies show that wood has a lower environmental impact than other building materials such as steel in terms of energy use, production of greenhouse gases, air and water pollution and production of solid waste, from material extraction to construction and maintenance.



Wood is a Natural, Replenishable Material

Carbon sequestration:

As they grow, trees remove carbon dioxide (CO_2) from the air - a leading greenhouse gas that has been linked to global warming - and convert it to carbohydrates (in wood fiber) and water, with oxygen as a byproduct. Wood products store carbon naturally and become part of the solution to excess CO_2 in the atmosphere.



Wood is a Natural, Replenishable Material

Energy Efficiency:

According to the California Forest Products Commission, while wood products represent 47% of all raw materials in the U.S., the energy used to produce them is just 4% of the energy used to make all manufactured materials.

Compared to the energy required to produce a ton of wood, it takes:

- 126 times more energy to produce 1 ton of aluminum
- 24 times more energy to produce 1 ton of steel

- APA, The Engineered Wood Association

Insulating Properties

Due to its composition, wood is a natural insulator and ranks high in thermal performance. Wood fiber contains cells that trap air and create insulating pockets throughout the door. According to the Temperate Forest Foundation, wood is 415 times more efficient as an insulator than steel and 2,000 times more efficient than aluminum.

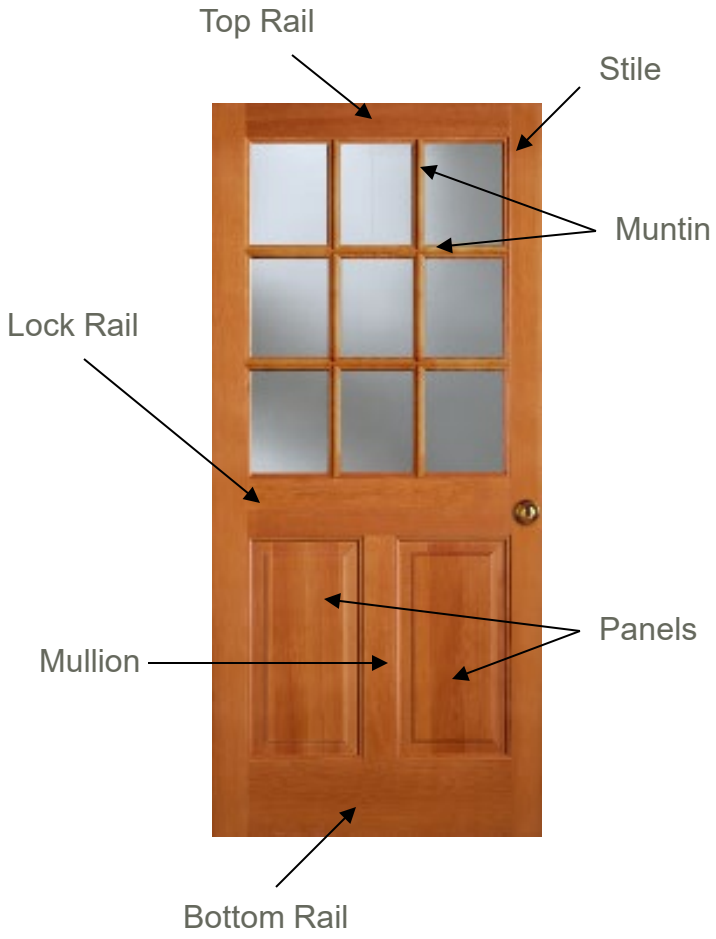
- Note: the majority of heat loss in an entryway occurs around the perimeter of the door (either between the door and door frame or between the door frame and rough opening). Therefore it is important to consider the complete entry system, including how the door is hung and weather-stripped, and how well the gap between the frame and rough opening is insulated.

Wood is also sound absorbent. Wood doors can help limit and/or control noise transmission in homes and buildings. In general, the thicker the wood door and its components, the better sound insulation it will provide.

Key Components of Stile & Rail Wood Doors

Exterior Wood Door Components

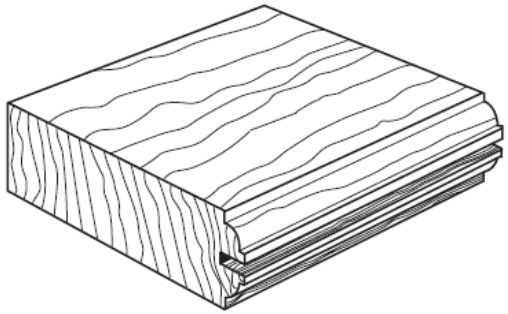
- Rails = horizontal components
- Stiles = vertical exterior components (left and right sides of the door)
- Muntin = a thin bar dividing glass units
- Mullion = vertical member between panels
- Panels = section(s) in between the stiles, rails and mutton.



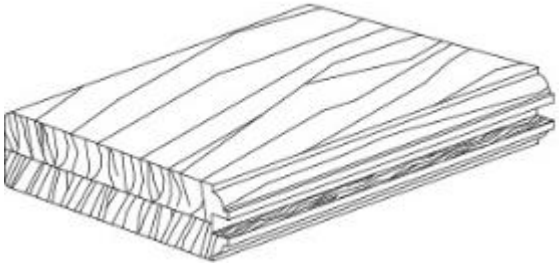
Solid vs. Engineered Construction

Most wood door manufacturers have evolved from solid to engineered lumber core construction, which offers increased durability, makes better use of the natural resource and resists warping, shrinking and splitting.

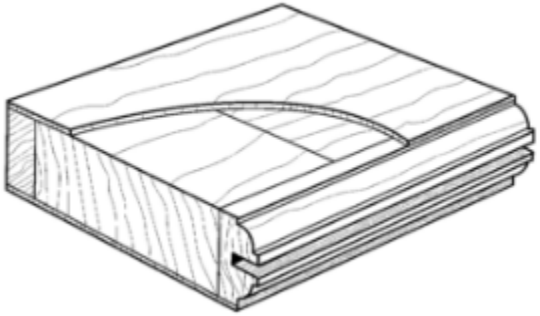
Engineered stiles, rails and muttons have solid lumber edges and face veneers over a composite core.



Solid Construction



Solid 2-Piece Laminated Construction

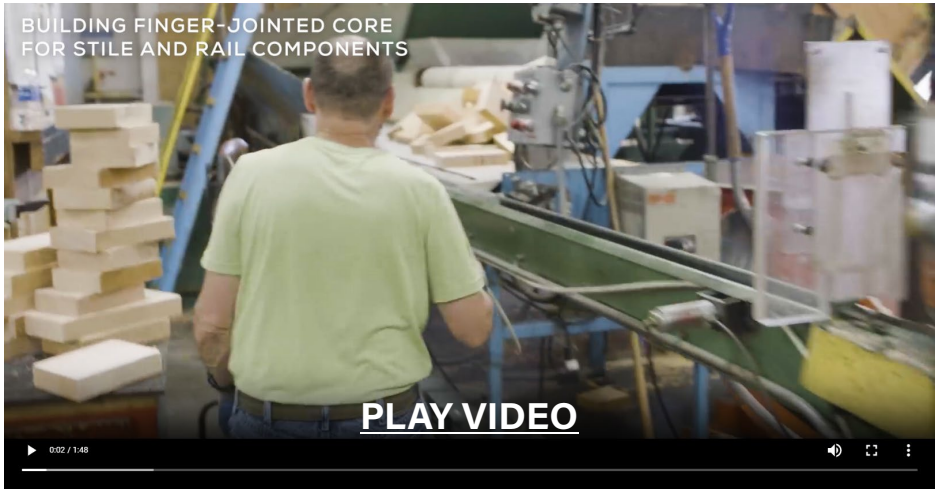


Engineered Construction

Engineered Stiles and Rails

FINGER-JOINTED ENGINEERED CORE

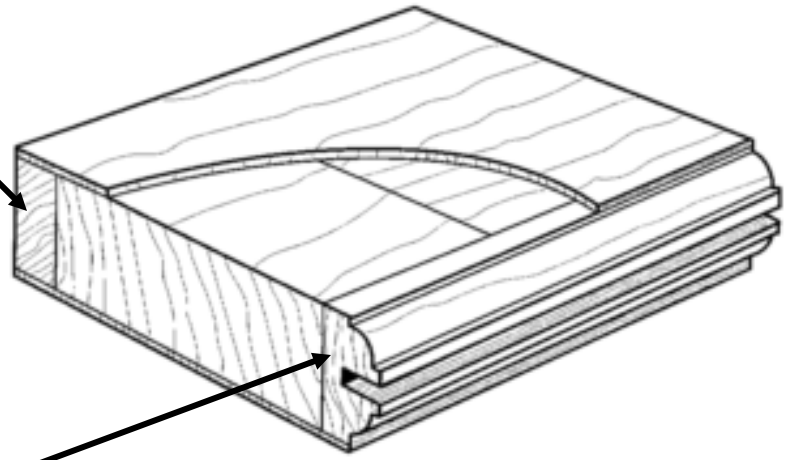
The finger-jointed core can perform better than a single piece of wood because the offsetting grain patterns resist the tendency to warp or twist. The resulting stile or rail stays straighter and truer in any climate. Finger-joints also have a greater gluing surface for added strength.



Engineered Stiles and Rails (Cont.)

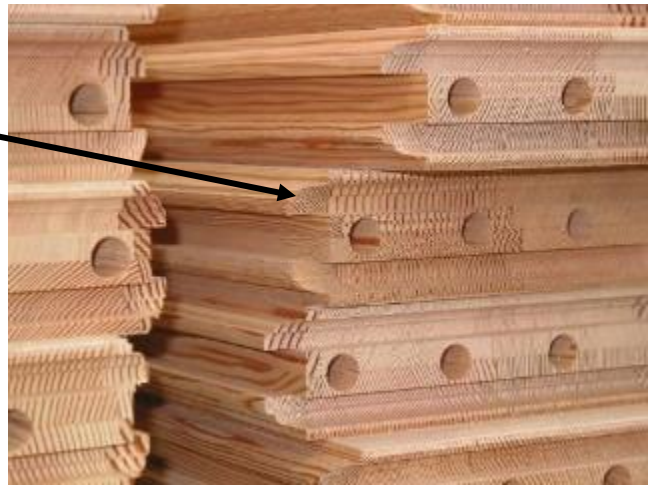
OUTER EDGE BAND (EDGE STRIP)

The edge band blends with the surface veneers so that the finger-jointed core is not visible.

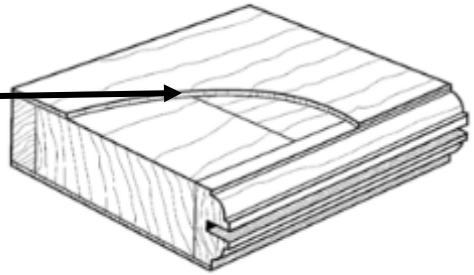


INNER EDGE BAND (EDGE STRIP)

Inner edge bands are provided so that no finger-joints show in the sticking, and it can be profiled to meet the design requirements of the door.

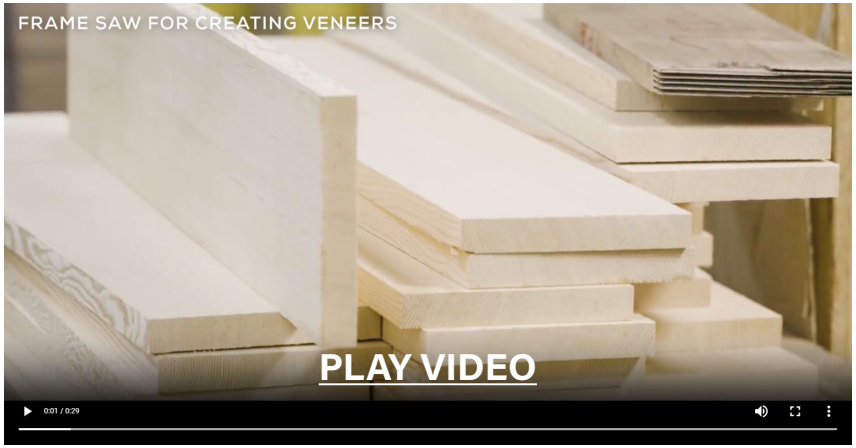


Engineered Stiles and Rails (Cont.)



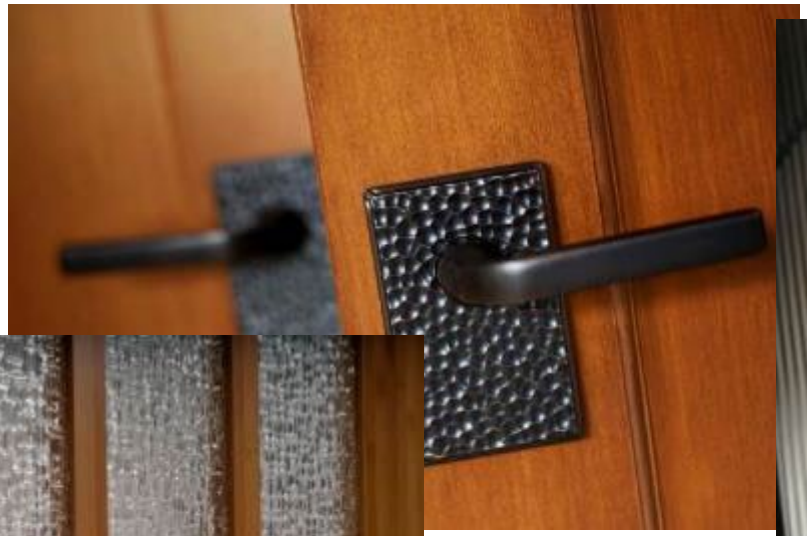
SURFACE VENEER

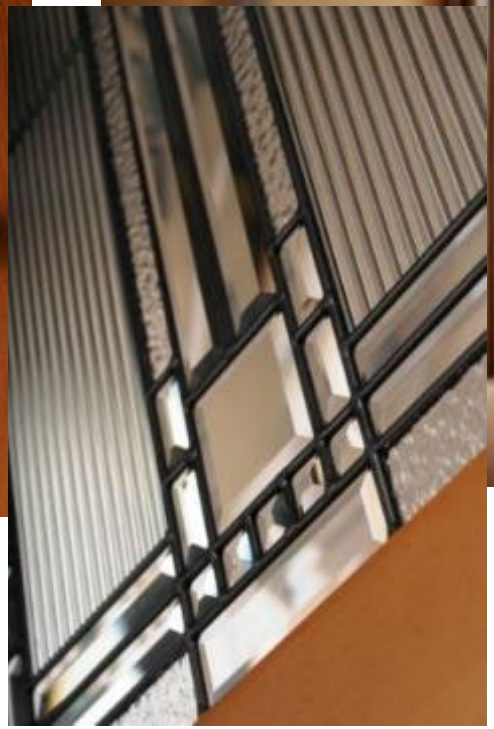
Specially selected veneer cants are sliced for the stile and rail faces. The cants are run through a hot water bath to soften the wood fibers to obtain a smooth slice without tearing the grain. The resulting veneers are dried to a similar moisture content as the core material. By using these selected veneers, surface quality is enhanced and the resource material can be extended further.



Design Details

Every minute feature, from the color of caming in glass to the carefully crafted, decorative detail in sticking and panels, has an impact on the look of a door. These seemingly small enhancements can make a big difference when trying to find the right door for a space. Therefore, manufacturers offer a wide selection of panel, glass, sticking and moulding profiles.





Panels

These are the most common panel profiles:

Flat panel

Single Hip Raised Panel

Double Hip Raised Panel

Glass

When it comes to glass options, the possibilities are seemingly endless. Most manufacturers offer a range of both clear textured and decorative glass, from transparent to obscure. For most exterior wood doors, insulated glass (dual- or triple-paned) is standard, while interior doors are typically single-glazed.

Some manufacturers will also sell their wood doors without the glass if the customer is interested in designing and installing their own.







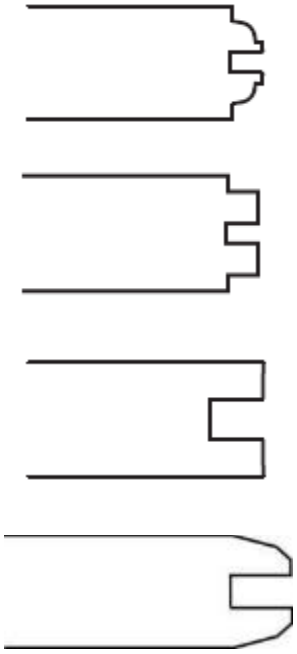


Sticking and Molding

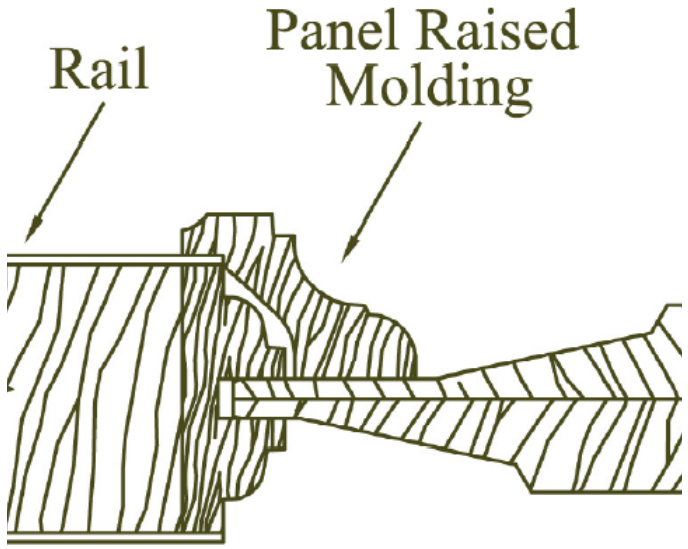
Sticking is the detail around the perimeter of the panel or glass unit. Optional raised molding sits on top of the panel and adjoining components (stiles, rails and/or muttons), providing a unique frame to the panel.

Common Sticking Profiles

- Ovolo sticking
- Square-Step sticking
- Shaker style = no sticking
- Bevel sticking



Raised Molding Example



Wood Door Manufacturing Process Key Steps

Preparing the Resource

Green lumber - sorting

Sorted lumber - pre-conditioning prior to slicing veneers. Lumber ready to go to the kilns. 10-14 days in the kiln - slow controlled drying.

Pre-conditioning for veneer slicing

Veneers after slicing

Stitching veneers together
for wider components

Making Engineered Components

Core material blanks

Core material with edge strips

Veneers applied to face of component

Making Engineered Components

Components
trimmed and profiled

Bored to accept
dowel pins

Rails with dowel pins
inserted

Panels and Specialty Components

Panels and specialty components being prepped for assembly

Door Assembly

Parts collected and staged for assembly

Assembled by hand by a door sapper

Finishing Touches

Assembled doors ready to be trimmed and sanded

Final door inspection

Preparing to be poly-bagged and cartoned

Common Differences Between Interior & Exterior Stile & Rail Doors

Interior Doors

- Predominantly 1-3/8”, but can be 1-3/4” thick
- Typically 1/8” thick single-glazed

Functional variations

- Lighter weight
- Fire-rated options
- Design flexibility to include materials not suited for exterior applications

Common Differences Between Interior & Exterior Stile & Rail Doors

Exterior Doors

- Predominantly 1-3/4”, but can be 2-1/4” thick
- Typically with ¾” insulated glass

Functional variations

- Stronger
- Noise reduction
- Weather protection
- Thicker components

Moisture Protection

Moisture & Wood Doors

Wood is a hygroscopic material, which means it readily exchanges moisture with the environment. Under normal conditions, all wood products contain some moisture, whether they are raw or finished. Although a finish will greatly slow this process, wood can still react to changes in humidity and environment.

Wood does not change size or shape unless its moisture content changes due to humidity conditions. When humidity is high, wood absorbs moisture and swells. In low humidity, wood releases moisture and shrinks.

The moisture content of wood is measured with a moisture meter, which displays the reading as a percentage. Wood for interior woodwork, including exterior and interior wood doors in centrally heated homes and offices, needs to be dried to at least 10 percent moisture content (MC).

For stile and rail doors, it is important that all component parts of a door be at a similar moisture content, so they expand and contract at the same rate.

Moisture & Wood Doors

Many manufacturers take great care in drying lumber to ensure that it happens at a rate at which no damage is done to the lumber and it can still yield components free of cracks (checks), cupping or twisting. Kilns are used to execute this process.

Dry lumber has done most of its contracting during the kiln-drying process and will stay more or less at the dimension it is after coming out of the kiln as long as it is stored properly or immediately used. Engineered or composite components further restrict movement with their unique composition made up of smaller pieces that are glued and/or finger-jointed together.

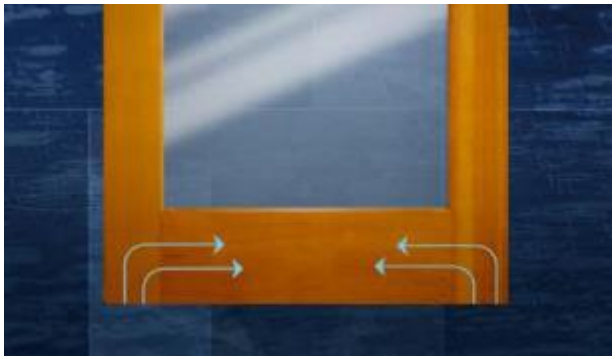
Moisture & Wood Doors

Likewise in the field, a wood door will perform better in the long term if it is finished as soon as possible. Doors left unfinished in an uncontrolled environment are more susceptible to problems.

Points of Moisture Vulnerability

The rate at which a door ages - and the frequency of maintenance it requires - are significantly affected by the amount of exposure to sun and rain. When left unprotected, repeated exposure to rain, sunlight and standing water can cause problems with warping, increasing maintenance and in some cases decreasing the overall life of the door.

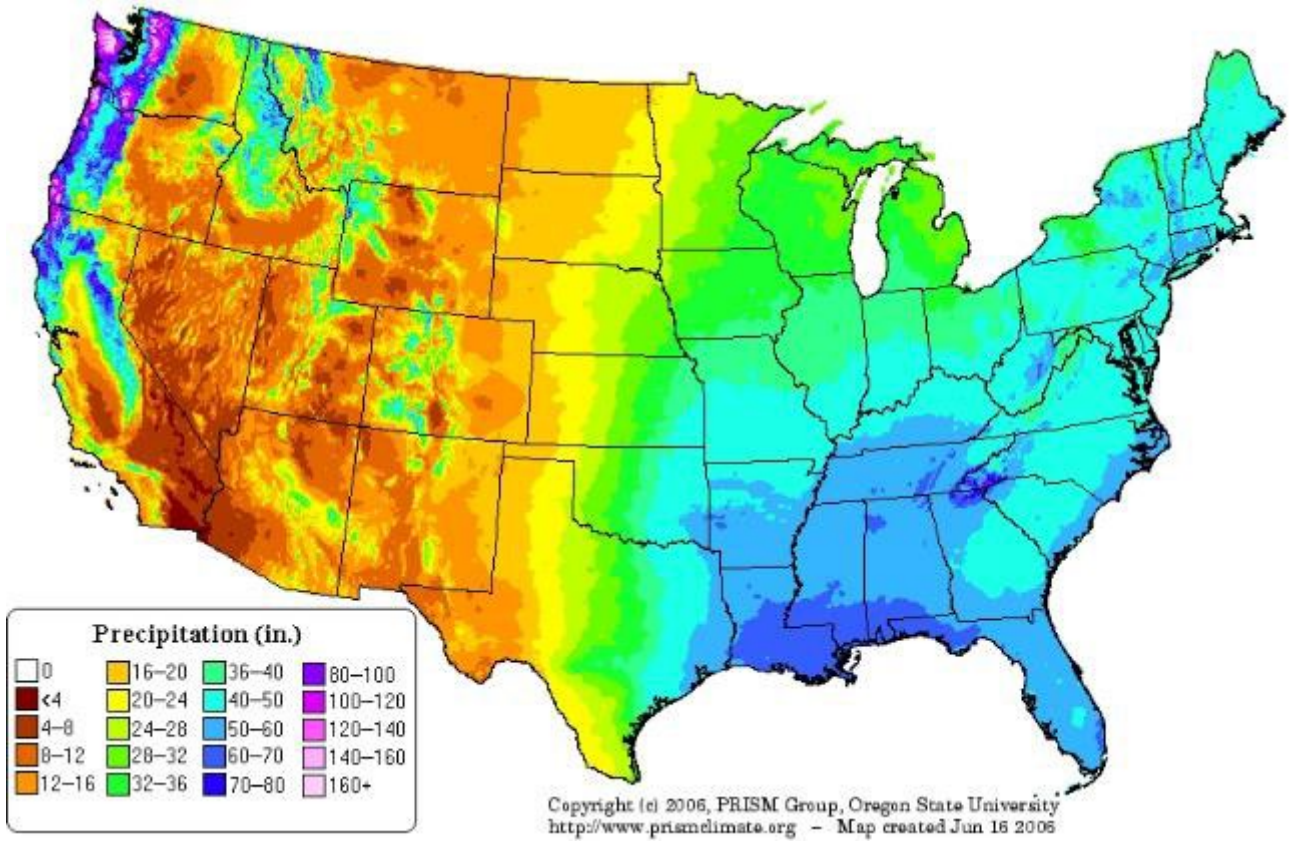
Research has shown the most susceptible area to moisture infiltration in exterior wood doors is at the bottom of the stiles, which commonly feature end grain.



If left unprotected, the path moisture infiltration follows

Advanced Manufacturing Technologies

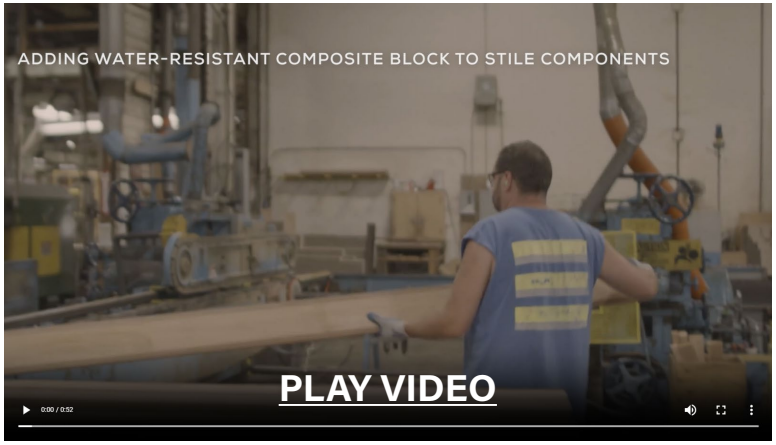
For areas subject to harsh weather, some wood door manufacturers have added to their list of options for exterior doors new technologies that provide improved resistance against water infiltration.

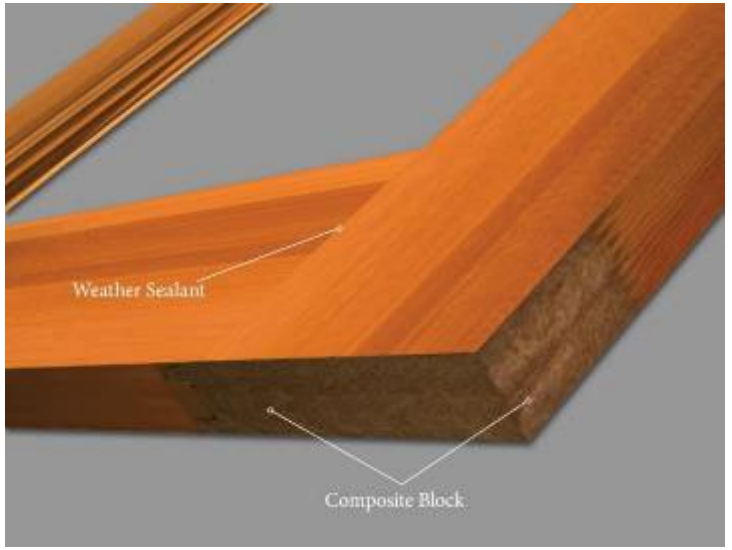


Battling Water Infiltration

There are processes in the marketplace that address water infiltration, which typically occurs at the bottom of the stiles. One technology, for example, combines a composite block finger-jointed into the engineered core at the bottom of the stiles, with a weather sealant in the stiles and bottom rail joints for additional protection against moisture penetration.

The additional protection that the composite block and weather sealant provide helps minimize stile and rail separation and reduce buckling, swelling and warping of the bottom rail and lower stile components.



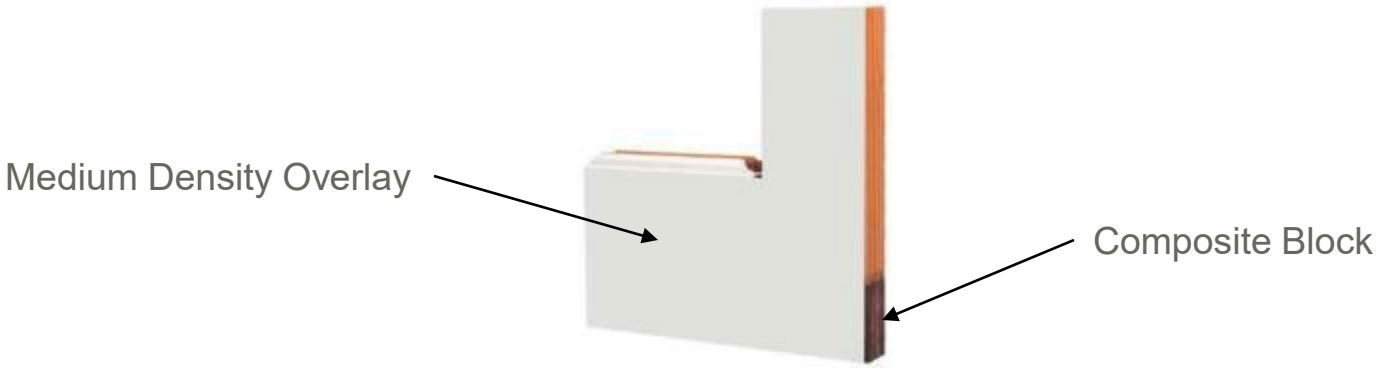


Battling Water Infiltration

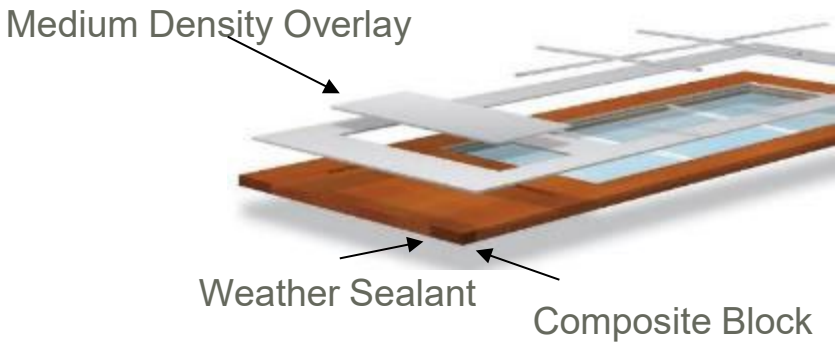
For partially to fully exposed exterior wood doors installed in tough climates, additional protection may be necessary.

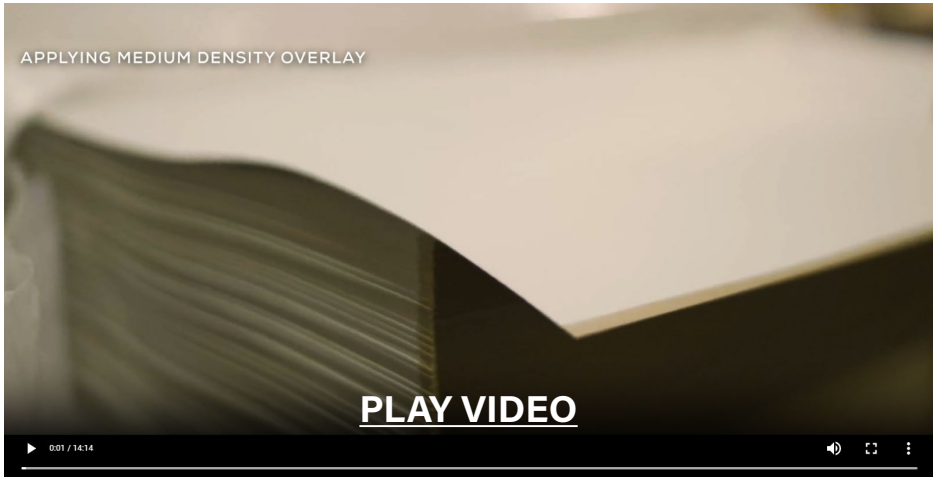
Additional options for increasing moisture resistance include an alternative to expensive cladded doors, which combines a Medium Density Overlay (MDO) with a PVC glazing bead to create an exterior that is impervious to moisture. The result is a door with superior water protection on the outside and the beauty of a real wood door on the inside.

This type of overlay, typically used for the rigorous applications required by traffic signs and concrete formwork, is manufactured using phenolic resin treated fiber. This gives the MDO overlay an extremely durable and smooth finish that is easy to paint and can withstand continuous exposure to rain, sun, insects and other outdoor hazards.



Battling Water Infiltration





Benefits of having a Medium Density Overlay on a wood door:

- Minimizes the possibility of stile and rail separation
- Eliminates checking on the face of the door
- Excellent durability and resists moisture absorption
- Compatible with water or alkyd-based paints on finish
- Beauty of wood on the inside of the door with superior protection on the outside

Additional Protection

In addition to door type and climate, several other factors influence the maintenance requirements and longevity of exterior wood doors and therefore must be considered to provide adequate protection from moisture, sun damage and weathering. These include:

- Exposure
- Installation
- Finishing
- Maintenance
- Storm Doors

Exposure

For best performance, exterior wood doors should be installed under a protective overhang to limit or eliminate direct exposure. Adequate overhang depends on the typical weather conditions of the area where the door is installed, but as a rule of thumb, the overhang should project a distance from the structure equal to at least one-half the distance between the bottom of the overhang and the bottom of the door.

For example, in the figure to the right, if Y = 8 feet, then X should = at least 4 feet **(X = ½ of Y)**.

If the doorway does not feature this overhang, there are options – the MDO overlay – that perform well in this application and carry an extended warranty.

Check local building codes for specific requirements.

Installation

When fitting and hanging an exterior wood door, there are a few precautions that must be taken. Design professionals should work with the contractor to ensure:

- There is adequate clearance for swelling of the door or frame in damp weather. Allow approximately 3/16" clearance for swelling when the door is installed in fully dry conditions. Jambs must be plumb.

- Doors are not cut down in height by more than 2" (1-1/2" maximum from bottom, 1/2" maximum from top). Care should be taken in cutting doors down in width—no more than 1/8” from each side is recommended—to avoid exposing engineered components. Use a sharp fine-tooth saw for trimming ends of doors.

- Caution is used to avoid impairing the strength of the door when fitting for locks. Allow at least 1" of wood back of mortise.

Installation (cont'd)

- There are three hinges on doors up to 7' in height and four hinges on doors over 7'. Hinges must be set in a straight line to prevent distortion.
- Multi-point locks should be considered for doors over 7' tall. See warranties to ensure requirements are met.
- Jambs and stops are set square and plumb.
- Weather-stripping is used to minimize heat loss and save energy.

Preparation For Finishing

Wood doors can be sold factory finished or unfinished. If unfinished, the door must be finished by either the door dealer, a contractor, specialty finisher or the purchaser. Manufacturers provide step-by-step instructions for best results from finishing, and those steps typically must be followed to ensure warranty requirements. In general, there are a few steps that need to be taken prior to finishing.

1. Sand the entire surface lightly with a 5/0 sandpaper (180 grit) to remove fingerprints and handling marks.
2. After sanding, clean the door thoroughly with a cloth to remove all dust.
3. If necessary, adjust or align components. Wood panels “float” and may be knocked into alignment with a wood block and hammer.
4. Hang door and then remove to finish. Door must be properly sealed prior to prolonged storage, installation of hardware or exposure to moisture or weather.

Finishing

Whether staining or painting, an exterior wood door should be:

- Finished before installation (prior to exposure) and done in accordance with the instructions provided by the manufacturer

- Finished on all six sides (including the top and bottom) to ensure complete protection. If all six sides are not finished, the warranty may be voided. Further, if a door is trimmed down to fit an opening, the newly exposed area should be immediately sealed.

- Finished with lighter colors. In general, darker colors absorb more UV rays and more heat than lighter colors. When exposed to the sun, the exterior side of a door can reach high temperatures. If it gets too hot, finish deterioration and accelerated color fading can occur. In hot climates, light colors can help reflect the heat and reduce heat build-up. For this reason, many wood door manufacturers require customers to use light colors and avoid dark stains and paints in order to keep the door's warranty.

Note: If a door contains glass, the glass should be protected during the finishing process.

Staining

When staining exterior doors, multiple steps are required:

- The first coat should be a stain-and-sealer, which colors the door and seals the surface. Available in a wide range of colors, stain-and-sealer should have an alkyd-resin base - under no circumstance should a lacquer-base toner or finish be used on exterior doors.
- The second and third coats (two top coats minimum) may be solvent-borne (oil-base, alkyd or polyurethane resin-base) or a water-borne (latex resin-base) clear finish. The advantages and disadvantages of solvent vs. water-borne finishes are:
  - Solvent-borne: faster drying, harder and more water resistant. May be applied under variable weather conditions. Disadvantages: Subject to ultraviolet degradation and not as flexible as water-borne finish.
  - Water-borne: Very flexible, greater ultraviolet resistance, and good exterior durability. Disadvantages: Cannot be applied below 50º F, long drying period required, and may not fully cure for several weeks. Water-sensitive until cure is complete.

Painting

Either oil-base or acrylic resin-base exterior grade paints may be used with success on panel doors. Oil-base paints offer more resistance to the passage of water (liquid and vapor) than acrylic resin-base paints, but the latter have better durability and color retention.

Doors should be sealed with a good quality oil-base primer followed by two top coats of either an oil-base or acrylic resin-base paint. Of course, both primer and top coat should be made by the same manufacturer and designed to be used as a combination.

For questions about painting a wood door, contact a local paint dealer as they can often recommend suitable finish systems that work well in the region.

Maintenance

Wood doors can look great and last a long time, but in order to do so they require some simple, periodic maintenance, such as refinishing or finish touch-ups.

Here are some signs to watch out for when inspecting a wood door. These can indicate that it is time for easy-to-perform maintenance:

- Hairline cracks in the top coat of finish.
- Changes in the color of the finish.
- Changes in the texture of the finish, such as flaking or scaling.
- The finish is dull or chalky.

If a wood door is installed in a severe climate or it receives a lot of direct sunlight or rain, it may need to be examined and resealed or repainted more frequently.

Storm Doors

While storm doors can provide additional protection for exterior doors, in warm climates they may do more harm than good to a wood door. The heat that builds up between the two doors can cause damage such as warping, color fading, and wood joint separation on the wood door. If a storm door is desired, it is best to choose one that has interchangeable glass and window screen panels so that in the warmer months the glass panels can be replaced with the screen panels to prevent heat build-up.

Wood Doors Can Last For Many Years

Wood doors are beautiful, versatile and an environmentally sound choice. With a palette of wood species and countless design options to choose from, architects and designers can easily incorporate wood doors into interiors and exteriors to match existing décor and complement a range of architectural styles in both residential and light commercial applications.

While they won't rust or dent like some other materials, exterior wood doors do require periodic maintenance to uphold their beauty and withstand the test of time. With proper planning and care, exterior wood doors can last for many years in any climate.

Drive through a historical neighborhood and look at the front entry doors. They will be predominantly wood. Design professionals have recognized the beauty and performance of wood doors for generations. And today's wood doors are built better than ever, ensuring even better performance for generations to come.

Thank You

Thank you for your time.

This concludes The American Institute of Architects Continuing Education Systems Program.

Simpson® Door Company