Guide to American Hardwoods

Species
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Introduction

The hardwood forests of the Eastern United States contain a wide range of temperate hardwood species, that have been managed for commercial and non-commercial purposes since the turn of the century. The hardwood sawmilling and processing industry, which depends upon this resource, is the largest producer of sawn hardwood in the world. In recent years the USA has substantially increased exports, although 90% is still consumed in the US domestic market. There are now specialised stockists all over the world from whom these unique hardwoods are available. Lists are available from the American Hardwood Export Council’s regional offices, detailed on page 32. AHEC is supported by the main US hardwood trade associations, also listed.

The purpose of this publication is to provide designers, architects, specifiers and users with the generic species information needed for a range of applications in furniture, joinery, flooring, doors and interiors. Information on lumber grades is published separately in AHEC’s "An Illustrated Guide to Hardwood Lumber Grades". The US industry also produces and exports American Hardwood veneer, plywood, flooring, dimension stock, furniture parts and mouldings. Information on these is published in AHEC’s Products brochure in conjunction with this publication.

American Hardwoods vary according to region and the map below may be useful as a guide to provenance.
Common name:  
**American alder**  *Alnus rubra*

Other names: Red alder, Western red alder, Western alder

### DISTRIBUTION

West coast USA, principally the Pacific North West, where it is the most common commercial hardwood.

### GENERAL DESCRIPTION

Red alder is almost white when freshly cut but quickly changes on exposure to air to light brown with a yellow or reddish tinge. Heartwood is formed only in trees of advanced age and there is no visible boundary between sap and heartwood. The wood is fairly straight grained with a uniform texture.

### WORKING PROPERTIES

Red alder machines well and is excellent for turning and polishing. It nails, screws and glues well, and can be sanded, painted, or stained to a good finish. It dries easily with little degrade and has good dimensional stability after drying.

### PHYSICAL PROPERTIES

- **Specific Gravity:** 0.41
- **Average Weight:** 449 kg/m³ (12% M.C.)
- **Average Volumetric Shrinkage:** 10.1% (Green to 6% M.C.)
- **Modulus of Elasticity:** 9515 MPa
- **Hardness:** 2624 N

### DURABILITY

The wood is non-resistant to heartwood decay, liable to attack by the common furniture beetle but is permeable for preservation treatment.

### AVAILABILITY

**USA:** Reasonably available, but strictly limited by region.  
**Export:** Readily available in some markets but limited in others. Available in dimension stock and rough lumber.

### MAIN USES

Furniture, kitchen cabinets, doors, interior mouldings, turning, carving and kitchen utensils.
American ash  *Fraxinus spp*

Other names: Northern ash, Southern ash

**DISTRIBUTION**
Throughout the Eastern USA.

**GENERAL DESCRIPTION**
American ash is similar in appearance to European ash. The sapwood is light coloured to nearly white and the heartwood varies from greyish brown to light brown, to pale yellow streaked with brown. The wood is generally straight grained with a coarse uniform texture. The degree and availability of light coloured sapwood, and other properties, will vary according to the growing regions.

**WORKING PROPERTIES**
Ash machines well, is good in nailing, screwing and gluing, and can be stained and polished to a very good finish. It dries fairly easily with minimal degrade, and there is little movement in performance.

**PHYSICAL PROPERTIES**
Ash has very good overall strength properties relative to its weight. It has excellent shock resistance and is good for steam bending.

For additional information on structural applications see pages 24-25, and pages 26-30 for pre-treatment properties and exterior applications.

**DURABILITY**
Non-resistant to heartwood decay. The sapwood is liable to attack by powder post and the common furniture beetle. The heartwood is moderately resistant to preservative treatment, and the sapwood is permeable.

**AVAILABILITY**
USA: Readily available.

Export: Good availability as lumber and veneer. The lumber is often classified according to growing regions and marketed as Northern ash and Southern ash. It is sometimes separated for colour and sold as white ash (sapwood) or brown ash (heartwood).

Fraxinus nigra, black ash, may also be sold as brown ash.

**MAIN USES**
Furniture, flooring, doors, architectural interiors, high class joinery and moulding, kitchen cabinets, panelling, tool handles, sports goods and turning.

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<th>Poor</th>
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<tbody>
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<td>Machining</td>
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<td>Finishing</td>
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</table>

**Specific Gravity:** 0.60

**Average Weight:** 673 kg/m³

**Average Volumetric Shrinkage:** 10.7% (Green to 6% M.C.)

**Modulus of Elasticity:** 11,977 MPa

**Hardness:** 5871 N

* Values based on *Fraxinus americana*
Common name: **American aspen** *Populus tremuloides*

Other names:

**DISTRIBUTION**
Throughout USA, but commercially in the North Eastern USA.

**GENERAL DESCRIPTION**
Sapwood is white, blending into the light brown heartwood. The contrast between sap and heartwood is small. The wood has a fine uniform texture and is straight grained.

**WORKING PROPERTIES**
Aspen does not split when nailed, it machines easily with a slightly fuzzy surface, and turns, bores, and sands well. It takes paint and stain well to produce a good finish although care is required where the surface is fuzzy. It has low to moderate shrinkage and good dimensional stability. Aspen is a true poplar, and therefore has similar characteristics and properties to cottonwood and European poplar.

**PHYSICAL PROPERTIES**
The wood is light and soft, with low bending strength and stiffness, and medium shock resistance. It has a very low bending classification.

**DURABILITY**
Non-resistant to heartwood decay, and extremely resistant to preservative treatment.

**AVAILABILITY**
USA: Limited, and rarely available in thick stock.
Export: Limited due to low demand.

**MAIN USES**
Furniture parts (drawer sides), doors, mouldings, picture frames, interior joinery, toys, kitchen utensils. Matchsticks (USA). Important specialised uses include sauna laths because of its low conductivity of heat, and chopsticks.

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<thead>
<tr>
<th>Property</th>
<th>Rating</th>
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<tbody>
<tr>
<td>Specific Gravity:</td>
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<tr>
<td>(12% M.C.)</td>
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<tr>
<td>Average Weight:</td>
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<tr>
<td>(12% M.C.)</td>
<td></td>
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<tr>
<td>Average Volumetric Shrinkage:</td>
<td>9.2%</td>
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<tr>
<td>(Green to 6% M.C.)</td>
<td></td>
</tr>
<tr>
<td>Modulus of Elasticity:</td>
<td>8136 MPa</td>
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<tr>
<td>Hardness:</td>
<td>1557 N</td>
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</tbody>
</table>

**MACHINING**

**NAILING**

**SCREWING**

**GLUING**

**FINISHING**
Common name:  
**American basswood**  *Tilia americana*

Other names: Linden, American whitewood, American linn

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**DISTRIBUTION**
Eastern USA, principally the Northern and Lake States.

**GENERAL DESCRIPTION**
The sapwood of basswood is usually quite large and creamy white in colour, merging into the heartwood which is pale to reddish brown, sometimes with darker streaks. The wood has a fine uniform texture and indistinct grain that is straight.

**WORKING PROPERTIES**
Basswood machines well and is easy to work with hand tools making it a premier carving wood. It nails, screws, and glues fairly well and can be sanded, stained, and polished to a good smooth finish. It dries fairly rapidly with little distortion or degrade. It has a fairly large shrinkage but good dimensional stability when dry.

**PHYSICAL PROPERTIES**
The wood is light and soft with generally low strength properties and a poor steam bending classification.

**DURABILITY**
Non-resistant to heartwood decay, sapwood is liable to attack by common furniture beetle. The wood is permeable for preservation treatment.

**AVAILABILITY**
USA: Reasonable availability both for lumber and veneer, particularly from the Northern States.
Export: Available in a full range of thicknesses and specifications, although volumes can be limited, this may change as demand increases.

**MAIN USES**
Carving, turning, furniture, pattern-making, mouldings, interior joinery and musical instruments. An important specialised use is Venetian blinds.

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<tr>
<th>Property</th>
<th>Grade</th>
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<tbody>
<tr>
<td>Specific Gravity:</td>
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<td>Modulus of Elasticity:</td>
<td>10,067 MPa</td>
</tr>
<tr>
<td>Hardness:</td>
<td>1824 N</td>
</tr>
</tbody>
</table>
Common name:

**American beech** *Fagus grandifolia*

Other names:

**DISTRIBUTION**
Throughout Eastern USA, commercial concentration is in the Central and Middle Atlantic States.

**GENERAL DESCRIPTION**
The sapwood of American beech is white with a red tinge, while the heartwood is light to dark reddish brown. American beech tends to be slightly darker and less consistent than European beech. The wood is generally straight grained with a close uniform texture.

**WORKING PROPERTIES**
American beech works readily with most hand and machine tools. It has good nailing and gluing properties and can be stained and polished to a good finish. The wood dries fairly rapidly but with a strong tendency to warp, split and surface check. It is subject to a large shrinkage and moderate movement in performance.

**PHYSICAL PROPERTIES**
American beech wood is classed as heavy, hard, strong, high in resistance to shock and highly suitable for steam bending.

**DURABILITY**
Rated as non-resistant to heartwood decay, and liable to attack by common furniture beetle and longhorn beetle, but permeable for preservation.

**AVAILABILITY**
**USA:** Mostly limited to lower grades.
**Export:** Very limited, due to low demand and wide availability of European beech.

**MAIN USES**
Furniture, doors, flooring, internal joinery, panelling, brush handles and turning. It is particularly suitable for food containers as there is no odour or taste.

<table>
<thead>
<tr>
<th>Property</th>
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<tr>
<td>Specific Gravity:</td>
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<tr>
<td>(12% M.C.)</td>
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<tr>
<td>Average Weight:</td>
<td>721 kg/m³</td>
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<td>(12% M.C.)</td>
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<tr>
<td>Average Volumetric Shrinkage:</td>
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<tr>
<td>(Green to 6% M.C.)</td>
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<tr>
<td>Modulus of Elasticity:</td>
<td>11,859 MPa</td>
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<tr>
<td>Hardness:</td>
<td>5782 N</td>
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</table>

American beech is classed as heavy, hard, strong, high in resistance to shock and highly suitable for steam bending.
Common name: **American yellow birch**  *Betula alleghaniensis*

Other names:

DISTRIBUTION
Eastern USA, principally Northern and Lake States.

GENERAL DESCRIPTION
Yellow birch has a white sapwood and light reddish brown heartwood. The wood is generally straight grained with a fine uniform texture.

WORKING PROPERTIES
The wood works fairly easily, glues well with care, takes stain and polish extremely well, and nails and screws satisfactorily where pre-boring is advised. It dries rather slowly with little degrade, but it has moderately high shrinkage, so is susceptible to movement in performance.

PHYSICAL PROPERTIES
The wood of yellow birch is heavy, hard and strong. It has very good wood bending properties, with good crushing strength and shock resistance.

DURABILITY
Non-resistant to heartwood decay. Liable to attack by common furniture beetle. Moderately resistant to preservative treatment but sapwood is permeable.

AVAILABILITY
**USA:** Reasonable availability, but more limited if selected for colour, ie red birch (heartwood) or white birch (sapwood).

**Export:** Limited due to low demand, but increasing.

MAIN USES
Furniture, internal joinery and panelling, doors, flooring, kitchen cabinets, turning and toys.

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<thead>
<tr>
<th>Property</th>
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<tr>
<td><strong>MACHINING</strong></td>
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<td><strong>NAILING</strong></td>
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<td><strong>FINISHING</strong></td>
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Specific Gravity: 0.62 (12% M.C.)

Average Weight: 689 kg/m³ (12% M.C.)

Average Volumetric Shrinkage: 13.4% (Green to 6% M.C.)

Modulus of Elasticity: 13,859 MPa

Hardness: 5604 N
Common name: 
**American cherry** *Prunus serotina*

Other names: American black cherry

**DISTRIBUTION**
Throughout Eastern USA. Main commercial areas Pennsylvania, Virginia, West Virginia and New York States.

**GENERAL DESCRIPTION**
The heartwood of cherry varies from rich red to reddish brown and will darken on exposure to light. In contrast the sapwood is creamy white. The wood has a fine uniform straight grain, smooth texture, and may naturally contain brown pith flecks and small gum pockets.

**WORKING PROPERTIES**
Cherry is easy to machine, nails and glues well and when sanded, stained and polished, it produces an excellent smooth finish. It dries fairly quickly with moderately large shrinkage, but is dimensionally stable after kilning.

**PHYSICAL PROPERTIES**
The wood is of medium density with good wood bending properties, it has low stiffness and medium strength and shock resistance.

**DURABILITY**
Rated as resistant to heartwood decay. The sapwood is liable to attack by common furniture beetle, and the heartwood moderately resistant to preservative treatment.

**AVAILABILITY**
USA: Regionally available.
Export: Widely available in a full range of specifications and grades as both lumber and veneer.

**MAIN USES**
Furniture and cabinet making, high class joinery, kitchen cabinets, mouldings, panelling, flooring, doors, boat interiors, musical instruments, turning and carving.

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<th>Property</th>
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**Physical Properties**

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<th>Property</th>
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<tr>
<td>Specific Gravity (12% M.C.)</td>
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<td>Average Weight (12% M.C.)</td>
<td>561 kg/m³</td>
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<td>Average Volumetric Shrinkage (Green to 6% M.C.)</td>
<td>9.2%</td>
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<tr>
<td>Modulus of Elasticity</td>
<td>10,274 MPa</td>
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<tr>
<td>Hardness</td>
<td>4226 N</td>
</tr>
</tbody>
</table>
Common name: **American cottonwood** *Populus deltoides*

Other names: Eastern cottonwood, Eastern poplar, Carolina poplar

**PHYSICAL PROPERTIES**

Cottonwood is relatively light in weight. The wood is soft, and weak in bending and compression, and low in shock resistance. It has no odour or taste when dry.

**DURABILITY**

Non-resistant to decay.

**AVAILABLE**

USA: Widely available in lumber and veneer.

Export: May be limited in some markets (where demand is low).

**MAIN USES**

Furniture, furniture parts, interior joinery and mouldings, toys and kitchen utensils. A specialised use (USA) is Venetian blinds and shutters.

<table>
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<th>Property</th>
<th>Fair</th>
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<td>Machining</td>
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**SPECIES PHYSICAL**

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<th>Property</th>
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<tr>
<td>Specific Gravity</td>
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<tr>
<td>Average Weight</td>
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<tr>
<td>Average Volumetric Shrinkage</td>
<td>11.3% (Green to 6% M.C.)</td>
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<tr>
<td>Modulus of Elasticity</td>
<td>9466 MPa</td>
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<tr>
<td>Hardness</td>
<td>1913 N</td>
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</table>

**DISTRIBUTION**

Eastern USA, main commercial areas Middle and Southern States.

**GENERAL DESCRIPTION**

The sapwood is white and may contain brown streaks while the heartwood may be pale to light brown. It is a diffuse porous timber with a coarse texture. The wood is generally straight grained and contains relatively few defects. Cottonwood is a true poplar, and therefore has similar characteristics and properties to aspen and European poplar.

**WORKING PROPERTIES**

General machinability is fair, although tension wood is frequently present and can cause a fuzzy surface when cut, which in turn will require additional care when finishing. The wood glues well and has good resistance to splitting when nailing and screwing. It dries easily but may still have a tendency to warp, with small movement in performance.
Common name:
American red elm  Ulmus rubra

Other names: Slippery elm, brown elm

DISTRIBUTION
The Eastern to Mid-West USA.

GENERAL DESCRIPTION
Red elm has a greyish white to light brown narrow sapwood, with heartwood that is reddish brown to dark brown in colour. The grain can be straight, but is often interlocked. The wood has a coarse texture.

(American grey elm is now only available in very limited volume.)

WORKING PROPERTIES
The wood of red elm is fairly easy to work, it nails, screws and glues well, and can be sanded, stained and polished to a good finish. It dries well with minimum degrade and little movement in performance.

PHYSICAL PROPERTIES
Elm is moderately heavy, hard and stiff with excellent bending and shock resistance. It is difficult to split because of its interlocked grain.

DURABILITY
Rated as non-resistant to heartwood decay, and classed as permeable to preservatives.

AVAILABILITY
USA: Limited in both lumber and veneer as supply is threatened by Dutch elm disease, but more available in the south.

Export: Limited.

MAIN USES
Furniture, cabinet making, flooring, internal joinery, panelling and coffins.

Specific Gravity: 0.53
Average Weight: 593 kg/m³
Average Volumetric Shrinkage: 11%
Modulus of Elasticity: 10,274 MPa
Hardness: 3825 N
Common name: **American gum** *Liquidambar styraciflua*

Other names: Redgum, sapgum, sweetgum

**PHYSICAL PROPERTIES**

American gum is moderately hard, stiff and heavy and has a low steam bending classification.

**DURABILITY**

Rated as non-resistant to heartwood decay and liable to insect attack. The heartwood is moderately resistant to preservative treatment but the sapwood is permeable.

**AVAILABILITY**

USA: Readily available, often separated for colour and sold as sapgum (sapwood) and redgum (heartwood).

Export: Limited in some markets due to low demand. Increasingly popular.

**MAIN USES**

Cabinet making, furniture parts, doors, internal joinery, strips and mouldings, turning and rail ties. Good substitute for walnut when stained.
Common name:
American hackberry  Celtis occidentalis

Other names: Common hackberry

**DISTRIBUTION**
Eastern USA.

**GENERAL DESCRIPTION**
Hackberry is closely related to sugarberry (Celtis laevigata) and is a member of the elm family. There is little difference between sapwood and heartwood which is yellowish grey to light brown with yellow streaks. The wood is very susceptible to blue staining before and after kilning and has irregular grain, occasionally straight and sometimes interlocked, with a fine uniform texture.

**WORKING PROPERTIES**
The wood planes and turns well and is intermediate in its ability to hold nails and screws, and stains and polishes satisfactorily. Hackberry dries readily with minimal degrade. It has a fairly high shrinkage and may be susceptible to movement in performance.

**PHYSICAL PROPERTIES**
Hackberry is moderately hard, heavy and has medium bending strength, high shock resistance but is low in stiffness. It has a good steam bending classification.

**DURABILITY**
Non-resistant to heartwood decay. Liable to attack by forest longhorn and Buprestis beetle. The heartwood is moderately resistant to preservative treatment but the sapwood is permeable.

**AVAILABILITY**
USA: Reasonable in lumber but mainly in the thinner standard thicknesses, and lower grades.
Export: Limited due to low demand, and concerns about internal staining.

**MAIN USES**
Furniture and kitchen cabinets, joinery, doors and mouldings.

<table>
<thead>
<tr>
<th>Property</th>
<th>Poor</th>
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<tbody>
<tr>
<td>Machining</td>
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<td>Finishing</td>
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- Specific Gravity: 0.53 (12% M.C.)
- Average Weight: 593 kg/m³ (12% M.C.)
- Average Volumetric Shrinkage: 13.5% (Green to 6% M.C.)
- Modulus of Elasticity: 8205 MPa
- Hardness: 3914 N
Common name:
American hickory and American pecan  Carya spp.

Other names:
American hickory  American pecan

DISTRIBUTION
Eastern USA, principal commercial areas
Central and Southern states.

GENERAL DESCRIPTION
The hickories are an important group within
the Eastern hardwood forests. Botanically they
are split into two groups; the true hickories,
and the pecan hickories (fruit bearing). The
wood is virtually the same for both and is
usually sold together. The sapwood of hickory
is white, tinged with brown while the
heartwood is pale to reddish brown. Both are
course textured and the grain is usually
straight but can be wavy or irregular.

WORKING PROPERTIES
The hickories are considered difficult to
machine and glue, and are very hard to work
with hand tools, so care is needed. They
hold nails and screws well, but there is a
tendency to split so pre-boring is advised. The
wood can be sanded and polished to
a good finish. It can be difficult to dry and has
a large shrinkage.

PHYSICAL PROPERTIES
The density and strength of the hickories will
vary according to the rate of growth, with the
true hickories generally showing higher values
than the pecan hickories. The wood is well
known for its very good strength and shock
resistance and it also has excellent steam
bending properties.

DURABILITY
Rated as non-resistant to heartwood decay.
The sapwood is liable to attack by the powder
post beetle. The wood is classed as resistant
to preservative treatment.

AVAILABILITY
USA: Readily available, more limited if
sold selected for colour as either
red or white hickory.
Export: Limited due to low demand.
Available only from specialist
importers in thin stock only.

MAIN USES
Tool handles, furniture, cabinetry, flooring,
wooden ladders, dowels and sporting goods.

<table>
<thead>
<tr>
<th>Property</th>
<th>True Hickory</th>
<th>Pecan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>a) 0.75</td>
<td>b) 0.66</td>
</tr>
<tr>
<td>(12% M.C.)</td>
<td>(12% M.C.)</td>
<td></td>
</tr>
<tr>
<td>Average Weight</td>
<td>a) 833 kg/m³</td>
<td>b) 737 kg/m³</td>
</tr>
<tr>
<td>(12% M.C.)</td>
<td>(12% M.C.)</td>
<td></td>
</tr>
<tr>
<td>Average Volumetric Shrinkage</td>
<td>a) 14.3%</td>
<td>b) N/A</td>
</tr>
<tr>
<td>(Green to 6% M.C.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>a) 15,583 MPa</td>
<td>b) 11,928 MPa</td>
</tr>
<tr>
<td>Hardness</td>
<td>a) N/A</td>
<td>b) 8095 N</td>
</tr>
</tbody>
</table>

a) Carya glabra (true hickory)  b) Carya illinoensis (pecan)
Common name: **American hard maple** *Acer saccharum, A. nigrum*

Other names: Sugar maple, black maple

**DISTRIBUTION**
Eastern USA, principally Mid-Atlantic and Lake States. A cold weather tree favouring a more Northerly climate.

**GENERAL DESCRIPTION**
The sapwood is creamy white with a slight reddish brown tinge and the heartwood varies from light to dark reddish brown. The amount of darker brown heartwood can vary significantly according to growing region. Both sapwood and heartwood can contain pith fleck. The wood has a close fine texture and is generally straight grained, but it can also occur as "curly", "fiddleback", and "birds-eye" figure.

**WORKING PROPERTIES**
Hard maple dries slowly with a large shrinkage, so it can be susceptible to movement in performance. Pre-boring is recommended when nailing and screwing. With care it machines well, turns well, glues satisfactorily, and can be stained and polished to an outstanding finish.

For additional information on structural applications see pages 24-25, and pages 26-30 for pre-treatment properties and exterior applications.

**PHYSICAL PROPERTIES**
The wood is hard and heavy with good strength properties, in particular its high resistance to abrasion and wear. It also has good steam bending properties.

**DURABILITY**
Rated as slightly or non-resistant to heartwood decay. Sapwood is liable to attack by furniture beetle. The heartwood is resistant to preservative treatment but the sapwood is permeable.

**AVAILABILITY**
USA: Widely available.
Export: Widely available as lumber and veneer. The higher quality grades of lumber are available selected for white colour (sapwood) although this can limit availability. Figured maple (birds-eye, curly, fiddleback) is generally only available in commercial volumes as veneer.

**MAIN USES**
Flooring, furniture, panelling, kitchen cabinets, worktops and table tops, interior joinery; stairs, handrails, mouldings, and doors.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>Poor</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACHINING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAILING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCREWING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLUING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FINISHING</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Specific Gravity: 0.63

Average Weight: 705 kg/m³

Average Volumetric Shrinkage: 11.9%

Modulus of Elasticity: 12,618 MPa

Hardness: 6450 N

* Values for *A. saccharum*
Common name: **American soft maple** Principally Acer rubrum, A. saccharinum

Other names: Red maple, silver maple

---

**PHYSICAL PROPERTIES**

Soft maple is about 25% less hard than hard maple, has medium bending and crushing strength, and is low in stiffness and shock resistance. It has good steam bending properties.

**DURABILITY**

Non-resistant to decay and insect attack. The heartwood is moderately resistant to preservative treatment but the sapwood is permeable.

**AVAILABILITY**

USA: Readily available as lumber and veneer. Export: Availability is improving as demand increases.

**MAIN USES**

Furniture, panelling, interior joinery, kitchen cabinets, mouldings, doors, musical instruments, and turning. Soft maple is often used as a substitute for hard maple or stained to resemble other species such as cherry. Its physical and working properties also make it a possible substitute for beech.
Common name:  
**American red oak** *Quercus spp*

Other names: Northern red oak, Southern red oak

### PHYSICAL PROPERTIES

The wood is hard and heavy, with medium bending strength and stiffness and high crushing strength. It is very good for steam bending. Southern red oak has a more rapid growth than Northern red oak and tends to be harder and heavier.

### DURABILITY

Rated slightly to non-resistant to heartwood decay, moderately easy to treat with preservatives.

### GENERAL DESCRIPTION

The sapwood of red oak is white to light brown and the heartwood is a pinkish reddish brown. The wood is similar in general appearance to white oak, but with a slightly less pronounced figure due to the smaller rays. The wood is mostly straight grained, with a coarse texture. The red oak tree gets its name because of the colour of the leaves in the “fall” (Autumn).

### DISTRIBUTION

Widespread throughout Eastern USA. The oaks are by far the largest species group growing in the Eastern hardwood forests. Red oaks grow more abundantly than the white oaks. The red oak group comprises many species, of which about eight are commercial.

### WORKING PROPERTIES

Red oak machines well, nailing and screwing is good although pre-boring is recommended, and it can be stained and polished to a good finish. It dries slowly with a tendency to split and warp. It has a high shrinkage and can be susceptible to movement in performance.

### PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Northern red oak</th>
<th>Southern red oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>a) 0.63</td>
<td>b) 0.68</td>
</tr>
<tr>
<td>Average Weight</td>
<td>a) 705 kg/m³</td>
<td>b) 753 kg/m³</td>
</tr>
<tr>
<td>Average Volumetric Shrinkage</td>
<td>a) 10.8</td>
<td>b) N/A</td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>a) 12,549 MPa</td>
<td>b) 15,721 MPa</td>
</tr>
<tr>
<td>Hardness</td>
<td>a) 5738 N</td>
<td>b) 6583 N</td>
</tr>
<tr>
<td>Machining</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Nailing</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Screwing</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Gluing</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Finishing</td>
<td>Poor</td>
<td>Good</td>
</tr>
</tbody>
</table>

For additional information on structural applications, see pages 24-25, and pages 26-30 for pre-treatment properties and exterior applications.

### MAIN USES

Construction, furniture, flooring, architectural interiors, internal joinery and mouldings, doors, kitchen cabinets, panelling, coffins and caskets. Not suitable for tight cooperage. Red oak can vary in colour, texture, characteristics and properties according to the growing region. It is therefore recommended that users and specifiers work closely with their suppliers to make sure the wood they order is suited to their specific needs.
Common name:
**American white oak** *Quercus spp*

Other names: Northern white oak, Southern white oak

### DISTRIBUTION
Widespread throughout Eastern USA. The white oak group comprises many species, of which about eight are commercial.

### GENERAL DESCRIPTION
White oak is similar in colour and appearance to European oak. The sapwood of American white oak is light coloured and the heartwood is light to dark brown. White oak is mostly straight grained with a medium to coarse texture, with longer rays than red oak. White oak therefore has more figure.

### WORKING PROPERTIES
White oak machines well, nails and screws well although pre-boring is advised. As it reacts with iron, galvanised nails are recommended. Its adhesive properties are variable, but it stains and polishes to a good finish. The wood dries slowly and care is needed to avoid checking. Due to its high shrinkage, it can be susceptible to movement in performance.

### PHYSICAL PROPERTIES
A hard and heavy wood with medium bending and crushing strength, low in stiffness, but very good in steam bending. Southern white oak is faster grown with wide growth rings, and tends to be harder and heavier.

### DURABILITY
The heartwood is resistant to decay, extremely resistant to preservative treatment, and the sapwood is moderately resistant to treatment.

### AVAILABILITY
**USA:** Readily available but not as abundant as red oak.

**Export:** Very widely available in lumber and veneer, in a full range of qualities and specifications. The most important hardwood export.

### MAIN USES
Construction, furniture, flooring, architectural joinery, exterior joinery, mouldings, doors, kitchen cabinets, panelling, railway sleepers, timber bridges, barrel staves, coffins and caskets.

White oak can vary in colour, texture, characteristics and properties according to the growing region. It is therefore recommended that users and specifiers work closely with their suppliers to make sure the wood they order is suited to their specific needs. Northern and Southern may be sold separately.

For additional information on structural applications see pages 24-25, and pages 26-30 for pre-treatment properties and exterior applications.
Common name: **American sassafras** *Sassafras albidum*

Other names: Golden elm

**DISTRIBUTION**
Eastern USA.

**GENERAL DESCRIPTION**
Sassafras heartwood is pale brown to orange brown, resembling ash or chestnut. The narrow sapwood is yellowish white. The wood has a coarse texture and is generally straight grained. Well known as an aromatic species.

**WORKING PROPERTIES**
Sassafras is easily worked and takes a finish well. It glues well and holds screws better than it nails, where pre-boring may be necessary to avoid splitting. It requires care in drying as it has a tendency to check with small movement in performance.

**PHYSICAL PROPERTIES**
Medium strength in all categories except stiffness which is low. Suitable for steam bending.

**DURABILITY**
Sassafras is very resistant to heartwood decay, in exposed damp conditions. The sapwood is liable to attack by powder post beetle. The heartwood is moderately resistant to preservative treatment but the sapwood is permeable.

**AVAILABILITY**
USA: Limited as lumber and veneer.
Export: Lumber extremely limited, veneer more available.

**MAIN USES**
Furniture, interior and exterior joinery, windows, doors and door frames and kitchen cabinets.
Common name:
**American sycamore** *Platanus occidentalis*

Other names: Buttonwood, American planetree

**DISTRIBUTION**
Throughout Eastern USA.

**GENERAL DESCRIPTION**
The sapwood of sycamore is white to light yellow, while the heartwood is light to dark brown. The wood has a fine close texture with interlocked grain. It is not related in any way to European sycamore but it has the same family classification, and similar characteristics to European plane. Contrasts well with other species.

**WORKING PROPERTIES**
The wood machines well, but high speed cutters are needed to prevent chipping. It is resistant to splitting due to the interlocked grain. The wood glues well and stains and polishes, with care, to an excellent finish. It has moderate shrinkage and little movement in performance.

**PHYSICAL PROPERTIES**
The wood is classified as moderate in weight, hardness, stiffness and shock resistance. It turns well on the lathe and has good bending qualities.

**DURABILITY**
Rated as non-resistant to heartwood decay. The sapwood is liable to attack by the common furniture beetle, but is permeable to preservative treatment.

**AVAILABILITY**
USA: Reasonable availability in a range of specifications and grades in lumber and veneer.

Export: Limited, due to sporadic demand.

**MAIN USES**
Furniture, furniture parts (drawer sides), internal joinery, panelling and mouldings, flooring, kitchen ware, butchers blocks and veneered panels.
Common name:
**American tulipwood** *Liriodendron tulipifera*

Other names: Yellow poplar (USA), tulip poplar (USA), canary whitewood

**DISTRIBUTION**
Widespread throughout Eastern USA.

**GENERAL DESCRIPTION**
The sapwood is creamy white and may be streaked with the heartwood varying from pale yellowish brown to olive green. The green colour in the heartwood will tend to darken on exposure to light and turn brown. The wood has a medium to fine texture and is straight grained. The size of the sapwood and some physical characteristics will vary according to growing regions. The wood has many desirable characteristics and is suitable for a wide variety of important uses. The tulipwood tree resembles the shape of the European poplar, hence its name in USA.

**WORKING PROPERTIES**
A versatile timber that is easy to machine, plane, turn, glue and bore. It dries easily with minimal movement in performance and has little tendency to split when nailed. It takes and holds paint, enamel and stain exceptionally well.

**PHYSICAL PROPERTIES**
A medium density wood with low bending, shock resistance, stiffness and compression values, with a medium steam bending classification.

**DURABILITY**
Non-resistant to decay, heartwood is moderately resistant to preservative treatment, sapwood is permeable.

**AVAILABILITY**
USA: Very widely available.
Export: Widely available in a full range of standard thicknesses and specifications.

**MAIN USES**
Light construction, furniture, interior joinery, kitchen cabinets, doors, panelling, mouldings, edged-glued panels, plywood (USA), turning and carving.

For additional information on structural applications see pages 24-25, and pages 26-30 for pre-treatment properties and exterior applications.

<table>
<thead>
<tr>
<th>Property</th>
<th>Poor</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nailing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screwing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finishing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Specific Gravity:** 0.42
- **Average Weight:** 449 kg/m³ (12% M.C.)
- **Average Volumetric Shrinkage:** 9.8% (Green to 6% M.C.)
- **Modulus of Elasticity:** 10,894 MPa
- **Hardness:** 2402 N
Common name:
American black walnut  *Juglans nigra*

Other names: Black walnut, American walnut

**DISTRIBUTION**
Throughout eastern USA, but principal commercial region is the Central States. One of the few American species planted as well as naturally regenerated.

**GENERAL DESCRIPTION**
The sapwood of walnut is creamy white, while the heartwood is light brown to dark chocolate brown, occasionally with a purplish cast and darker streaks. Walnut can be supplied steamed, to darken sapwood or left unsteamed. The wood is generally straight grained, but sometimes with wavy or curly grain that produces an attractive and decorative figure.

**WORKING PROPERTIES**
Walnut works easily with hand and machine tools, and nails, screws and glues well. It holds paint and stain very well and can be polished to an exceptional finish. It dries slowly, and care is needed to avoid kilning degrade. Walnut has good dimensional stability.

**PHYSICAL PROPERTIES**
Walnut is a tough hard timber of medium density, with moderate bending and crushing strengths and low stiffness. It has a good steam bending classification.

**DURABILITY**
Rated as very resistant to heartwood decay, it is one of the most durable woods even under conditions favourable to decay. Sapwood liable to attack by powder post beetles.

**AVAILABILITY**
USA: Reasonable availability with regional limitations.
Export: Reasonable availability in both lumber and veneer.

**MAIN USES**
Furniture, cabinet making, architectural interiors, high class joinery, doors, flooring, and panelling. A favoured wood for using in contrast with lighter coloured timbers.

<table>
<thead>
<tr>
<th>Property</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machining</td>
<td>Fair</td>
</tr>
<tr>
<td>Nailing</td>
<td>Poor</td>
</tr>
<tr>
<td>Screwing</td>
<td>Poor</td>
</tr>
<tr>
<td>Gluing</td>
<td>Poor</td>
</tr>
<tr>
<td>Finishing</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**PHYSICAL PROPERTIES**
Specific Gravity: 0.55 (12% M.C.)
Average Weight: 609 kg/m³ (12% M.C.)
Average Volumetric Shrinkage: 10.2% (Green to 6% M.C.)
Modulus of Elasticity: 11,584 MPa
Hardness: 4492 N
Common name: **American willow** *Salix spp.*

Other names: Black willow, swamp willow

**Physical Properties**

The wood is weak in bending, compression, shock resistance and stiffness, with a poor steam bending classification.

**Durability**

Non-resistant to hardwood decay. The heartwood is resistant to preservative treatment and the sapwood is permeable.

**Availability**

USA: Reasonable availability on a regional basis, as lumber and veneer.

Export: Very limited indeed due to low demand.

**Main Uses**

Furniture, joinery, interior mouldings, panelling, doors, sports equipment, kitchen utensils and toys.

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**DISTRIBUTION**

Eastern USA. Principal commercial areas are the Middle and Southern States, along the Mississippi river.

**General Description**

The sapwood of willow varies in width according to growing conditions and is light creamy brown in colour. In contrast the heartwood is pale reddish brown to greyish brown. The wood has a fine even texture and although generally straight grained it can sometimes be interlocked, or display figure.

**Working Properties**

Willow works fairly easily with hand and machine tools but care is needed to avoid a fuzzy surface when interlocked grain is present. The wood nails and screws well, glues excellently, and can be sanded and polished to a very good finish. It dries fairly rapidly with minimal degrade although may be susceptible to moisture pockets. Dimensional stability is good when dry.

**Physical Properties**

Specific Gravity: 0.39

Average Weight: 417 kg/m³

Average Volumetric Shrinkage: 11.5%

Modulus of Elasticity: 6960 MPa

Hardness: N/A

* Values for *Salix nigra*
Glossary of terms

Checks: Longitudinal separation of the fibres in wood that do not go through the whole cross section. Checks result from tension stresses during the drying process.

Decay: The decomposition of wood substance by fungi (other terms: rot, dote)

Density: Weight per unit volume. Density of wood is influenced by rate of growth, percentage of late wood and in individual pieces, the proportion of the heartwood.

Durability: The resistance of wood to attack by decay fungi, insects and marine borers.

Dimensional Stability: A term that describes whether a section of wood will resist changes in volume with variation in moisture content (other term: movement in performance).

Figure: The pattern produced in a wood surface by annual growth rings, rays, knots, deviations from regular grain, such as interlocked and wavy, and irregular colouration.

Grain: The direction, size, arrangement, appearance, or quality of the fibres in sawn wood. Straight grain is used to describe lumber where the fibres and other longitudinal elements run parallel to the axis of the piece.

Gum Pocket: An excessive local accumulation of resin or gum in the wood.

Hardness: The resistance of the wood against indentation and abrasion. Values are given in Newtons (N) and are a measure of the load required to embed a 11.3mm ball to one half its diameter in the wood.

Hardwood: A description applied to woods from deciduous and evergreen broad-leaved trees (Angiosperms). The term has no reference to the actual hardness of the wood.

Heartwood: The inner layers of wood in growing trees that have ceased to contain living cells. Heartwood is generally darker than sapwood, but the two are not always clearly differentiated.

Modulus of Elasticity: An imaginary stress necessary to stretch a piece of material to twice its length or compress it to half its length. Values for the individual species are given in megapascals (MPa - equivalent to N/mm²), and are based on testing small clear pieces of dry wood. The values given on page 25 are based on testing full sized pieces.

Moisture Content: The weight of water contained in wood expressed as a percentage of (M.C.): the weight of the oven dry wood.

Pith Flecks: Pith-like irregular discoloured streaks of tissue in wood, due to insect attack on the growing tree.

Sapwood: The outer zone of wood in a tree, next to the bark. Sapwood is generally lighter than heartwood, and lacks resistance to decay.

Shrinkage: The contraction of wood fibres caused by drying below the fibre saturation point (usually around 25-27% M.C.). Values are expressed as a percentage of the dimension of the wood when green.

Specific Gravity: The relative weight of a substance compared with that of an equal volume of water. S.G. values given are based on wood volume at 12% M.C. and oven dry weight.

Split: Separation of the fibres in a piece of wood from face to face (other term: end-split).

Stain: A variation from the natural colour of the wood or a discolouration that may be caused by micro-organisms, metal or chemicals. The term also applies to materials used to impart colour to wood.

Texture: Determined by relative size and distribution of the wood elements. Described as coarse (large elements), fine (small elements) or even (uniform size of elements).

Warp: Distortion in lumber causing departure from its original plane, usually developed during drying. Warp includes cup, bow, crook and twist.

Weight: The weight of dry wood depends upon the cellular space, i.e. the proportion of wood substance to air space. Values are given for each species in kg/m³ at 12% M.C.
Structural applications and strength properties

While the bulk of American hardwood is used for furniture and joinery, it may on occasion be considered for structural work, such as the stringers of a free-standing staircase, or the edge beam of the floor which supports it. This in turn creates a need for the strength properties of the species to be available in a form which can be used by engineers in conjunction with an appropriate design code, to validate a particular design.

Structural design in Europe

Over the last fifty years many European countries have developed national codes. For example, the UK code (BS 5268) gives ‘permissible stresses’ for various species, which embody the total factor of safety against failure. Other codes are in ‘limit state’ format, in which the total factor of safety is split between the material strengths and the applied forces.

In 1994 the first Eurocode for timber was issued (in limit state format), and although still a draft in 1998, it is accepted in some countries (including the UK) as an alternative to the national code. It was accompanied by Euronorms, which standardised test procedures (EN 408) and defined strength classes for softwoods and hardwoods (EN 338). As the use of the unified European codes and standards increases, it will be easier for designs, and designers, to cross national boundaries.

A programme of testing

Design information for softwoods is readily available, due to their general structural use, but there is currently no equivalent information relating to the American hardwoods. For this reason, AHEC have commissioned a programme of testing to be undertaken in Europe by the Building Research Establishment, UK. The tests will be carried out, and the characteristic values determined, in accordance with the relevant European Standards. It is proposed to test five species in all: red oak, white oak, ash, tulipwood and hard maple, which would then be allocated to a strength class of EN 338. The results will be published when available, but in the interim, design information for three species is given on page 25, based on testing work already carried out. They are related to material which passes the TH1 grade of BS 5756, the UK hardwood grading standard complying with the requirements of EN 518, which lays down the principles for visual grading standards.

Structural grades

Timber is a naturally variable material, and as a result, all commercial supplies are related to a particular grade from a set of published rules. Almost all the American hardwood available in Europe is graded to National Hardwood Lumber Association (NHLA) rules, mainly grades ‘Firsts and Seconds’ (FAS) and ‘No 1 Common’ (#1C).

Specific details of NHLA grading is contained in AHEC’s “An Illustrated Guide to Hardwood Lumber Grades”. All grading systems are designed for an end use. As would be expected, the NHLA rules relate to the appearance of the timber, for use in joinery and furniture. Therefore, to use this timber for structural work, it must be re-graded to an appropriate structural grading standard.

The rules of BS 5756 are straightforward, and relate to the defects covered by most grading standards, principally knot size and slope of grain. In practice, most FAS grade material would achieve a 90% pass rate when re-graded to TH1 grade of BS 5756.
Structural applications and strength properties

Structural properties for red oak, white oak, and hard maple for timber of TH1 grade, BS 5756

Grade stresses for use with BS 5268, a permissible stress code

<table>
<thead>
<tr>
<th>Strength class</th>
<th>Bending parallel to grain</th>
<th>Tension parallel to grain</th>
<th>Compression parallel to grain</th>
<th>Compression perpendicular to grain (no wane)</th>
<th>Shear parallel to grain</th>
<th>Modulus of elasticity Mean</th>
<th>Modulus of elasticity Minimum</th>
<th>Characteristic density Pk</th>
<th>Average density Pmean</th>
</tr>
</thead>
<tbody>
<tr>
<td>D30</td>
<td>9.0</td>
<td>5.4</td>
<td>8.1</td>
<td>2.8</td>
<td>1.40</td>
<td>9.500</td>
<td>6.000</td>
<td>530</td>
<td>640</td>
</tr>
</tbody>
</table>

Source BS 5268, Table 7

Characteristic values for use with a limit state code

<table>
<thead>
<tr>
<th></th>
<th>STRENGTH PROPERTIES (D30)</th>
<th>STIFFNESS PROPERTIES (D30)</th>
<th>DENSITY (D30)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bending</td>
<td>Tension parallel</td>
<td>Tension perpendicular</td>
</tr>
<tr>
<td></td>
<td>N/mm²</td>
<td>N/mm²</td>
<td>N/mm²</td>
</tr>
<tr>
<td>D30</td>
<td>30</td>
<td>18</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Source EN 338

Section prepared by Peter Ross, Associate Director, Ove Arup and Partners.
Pre-treatment properties and exterior applications

Many American hardwoods can, in practice, be used externally if the correct design, detailing and construction techniques have been adopted. Coupled with this procedure is the proper use of pre-treatments, end grain sealers and the selection of a coating system, suitable for the particular exposure conditions. In order to maintain the protective coating “envelope”, an on-going maintenance programme is recommended.

All wood species, including American hardwoods, vary in their natural resistance to wood-destroying fungi. The long term performance of American hardwoods can readily be achieved by correctly selecting from a range of preventative measures.

The first stage is to ensure an “in-service” moisture content below 20%. Wood destroying fungi cannot grow at this level of moisture content.

As the second stage, consideration should be given to the selection and use of naturally durable wood species. Apart from white oak, walnut, cherry and sassafras, most other commercial American hardwoods are classed as non durable.

Finally, where the “in-service” moisture content will exceed 20% or where the inherent natural durability of the wood is insufficient, pre-treatment with chemicals (preservatives) that are effective against wood-destroying fungi and/or insects is advisable. It is possible to obtain the required penetration and retention levels for many American hardwoods. Recent developments in the field of pre-treatment processes have made this possible.

Relevant European Standards

EN 350-2 : 1994... lists the natural durability of solid wood to wood-destroying fungi for selected species. A five class system is used to define the resistance of heartwood:

<table>
<thead>
<tr>
<th>Durability class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>very durable</td>
</tr>
<tr>
<td>2</td>
<td>durable</td>
</tr>
<tr>
<td>3</td>
<td>moderately durable</td>
</tr>
<tr>
<td>4</td>
<td>slightly durable</td>
</tr>
<tr>
<td>5</td>
<td>not durable (includes all sapwood)</td>
</tr>
</tbody>
</table>

Cross referencing the relevant hazard class contained within EN 335-2 : 1992 is recommended.

Substrate behaviour

To realise the optimum performance of American hardwoods, an understanding of the behaviour that individual species have on both the pre-treatment and coating system is required.

The principle influences are the natural wood extractives contained within the timber substrate. Some of the many properties they impart are colour, resistance to wood-destroying fungi and the uptake or release of moisture.

As all American hardwoods vary in colour, so will their respective natural properties. This balance of properties can have a marked effect on the finished appearance of an opaque coating. As the natural colour of American hardwoods is soluble (to some degree) in either water, alcohols or organic solvents, this can impact on several pre-treatment or coating processes.

Using American red oak as an example; variations in the degree of both penetration and retention can be experienced when an organic solvent preservative is used, resulting in variable drying of the pre-treatment and the subsequent coating material. The effects of overcoating should be considered, particularly if a water-borne coating system was specified, as this could affect adhesive performance and discolour the finish.
Pre-treatment properties and exterior applications

Pre-treatments

Wood preservatives are classified according to their efficacy in particular environments. The level of treatment is further classified by penetration into the timber and the retention or loading in a specified zone (irrespective of pre-treatment method or wood species). In this move towards “results”, as opposed to “process” orientated standards in Europe, an awareness of the latest technologies entering the marketplace, such as solvent free preservatives, are important.

EXAMPLES OF PRESERVATIVE TYPES
- Organic Solvent (e.g. Acypetacs Zinc)
- Vapour Phase Treatments (e.g. Boron)

METHODS OF APPLICATION
- Penetrating Treatment Process (examples are diffusion treatments, double-vacuum and vacuum pressure methods).
- Superficial Application Process (examples are brush and spray techniques and short-time immersion (dipping) processes in wood that normally has only a few minutes contact time with the preservative).

The Preservative Pre-treatment “Blueprint”
- the active ingredient must be effective against the target organism(s)
- the active ingredient must be permanent
- it should have the required penetration and retention values
- it should be safe
- it should be easy to use
- it should have a minimal effect on the timber’s properties, for example: overcoating, moisture content, residual odours, gluing, and handling

Influences On The Absorption Of Preservatives

Timber varies in its permeability to liquids, whether it is water or a wood preservative. Therefore, to be effective against a particular target organism, a degree of penetration (and subsequently, retention) is required.

Currently, there are nine penetration (minimum depth) classes, P1 to P9 (reference: EN 351-1 : 1995). The ability to meet a penetration class will depend on the treatability of the timber species concerned.

A four class system of treatability is currently in use (reference EN 350-2 : 1994) and is based upon general observations associated with penetrating treatment processes. The treatability classification cannot be precisely defined. In treatment, irregular penetration can often be expected.

Coating systems

Coating manufacturers are having to recognise and anticipate the increasing pressure being exerted to limit the levels of certain Volatile Organic Compounds (VOCs) in their products.

Due to the growth in environmental awareness, legislation has and will be enacted that will result in a continual reduction in the solvent content of surface coatings.

The legislation that will be introduced into the marketplace will influence the trend towards high solids, low solvent systems and will continue to gain momentum over the next 10 years, as solvent emissions in Western Europe are likely to come under further pressure for limitation by legislation.
Pre-treatment properties and exterior applications

Information on individual species and the influence of surface coatings

This section provides information on five commercially important American hardwood species; ash, hard maple, red oak, white oak and tulipwood. For all species the colour will vary depending upon their exposure to light. The appearance of a coating system will be strongly influenced by the original timber colour. The extent of this influence can be established by the utilisation of a trial area. All species samples shown in this publication were treated with Danish oil.

American ash  *Fraxinus spp.*

**Treatability**
- Heartwood - class 2 Moderately easy to treat
- Sapwood - class 1 Easy to treat

The above classification refers to a set of broad descriptions for classifying treatability based upon general observations associated with the use of penetrating treatment processes.

**Natural Durability To Wood-Destroying Fungi**
- Heartwood - class 5 not durable
- Sapwood - class 5 not durable

The above classification provides an indication of the currently accepted characteristics and performance of wood in ground contact.

**General**
A liberal coat of base stain (or primer) should be brush applied liberally and evenly so as to satisfy the timbers suction, by displacing the air in these cells. This principle can be applied to a factory situation, particularly when the first coat of base stain (or primer) should be dipped for a minimum 30 seconds of “contact time”.

Consider the use of a “grain” filler beneath opaque coating systems.

American hard maple  *Acer saccharum*

**Treatability**
- Heartwood - class 5 not durable
- Sapwood - class 5 not durable

**Natural Durability To Wood-Destroying Fungi**
- Heartwood - class 5 not durable
- Sapwood - class 5 not durable

**Moisture Movement**
- Classed as small.

EN 350-2 : 1994  American ash has not yet been appraised for inclusion. Therefore the following classifications for durability and treatability are based upon practical experience.

EN 942 : 1996  Based upon the above durability classification the natural durability is deemed insufficient for exterior applications.

EN 335-2 : 1992  Cross reference to ascertain the relevant hazard class.

EN 350-2 : 1994  American hard maple has not yet been appraised for inclusion. Therefore the following classifications for durability and treatability are based upon practical experience.
Pre-treatment properties and exterior applications

The above classification provides an indication of the currently accepted characteristics and performance of wood in ground contact.

EN 942 : 1996  Based upon the above durability classification the natural durability is deemed insufficient for exterior applications.

American hard maple can, in practice, be used externally if the correct design, detailing and construction techniques have been adopted, along with an effective preservative pre-treatment. To maintain the protective coating "envelope", an on-going maintenance programme is recommended.

EN 335-2 : 1992  Cross reference to ascertain the relevant hazard class.

Moisture Movement

EN 942 : 1996  Classed as medium.

Treatability

Heartwood -  class 3 Difficult to treat
Sapwood -  class 1 Easy to treat

The above classification refers to a set of broad descriptions for classifying treatability based upon general observations associated with the use of penetrating treatment processes.

American red oak - Quercus Spp

Natural Durability To Wood-Destroying Fungi

EN 350-2 : 1994  The following classification provides an indication of the currently accepted characteristics and performance of wood in ground contact.

Heartwood -  class 4 slightly durable
Sapwood -  class 5 not durable

The required preservative pre-treatment, and optimum penetration and retention values, have been demonstrated with vapour phase treatments (ie Vapour Boron).

General

A liberal coat of base stain (or primer) should be evenly applied to satisfy the timbers suction, by displacing the air in these cells. Consider the use of a “grain” filler beneath opaque coating systems.

This timber contains a high level of water soluble, natural wood extractives (acidic).

We would recommend thorough degreasing with a “sharp” solvent, so as to aid the adhesive performance of the base stain (or primer).
Pre-treatment properties and exterior applications

To minimise the influence of extractives, a primer (or base stain) that is resistant to discolouration is recommended. In addition, the use of non-ferrous fixings is strongly advised; as is the avoidance of wire wool. This will minimise the appearance of “iron staining”.

American white oak *Quercus Spp*

Natural Durability To Wood-Destroying Fungi

<table>
<thead>
<tr>
<th></th>
<th>EN 350-2 : 1994</th>
<th>The following classification provides an indication of the currently accepted characteristics and performance of wood in ground contact.</th>
</tr>
</thead>
</table>
| Heartwood | class 2 durable/class 3 Moderately durable |AMAGE
| Sapwood | class 5 not durable | The above classification provides an indication of the currently accepted characteristics and performance of wood in ground contact. |

EN 942 : 1996 Natural durability sufficient for exterior joinery. American white oak is therefore suitable for exterior use without preservative pre-treatment

EN 335-2 : 1992 Cross reference to ascertain the relevant hazard class.

Moisture Movement

EN 942 : 1996 Classed as medium.

Treatability

EN 350-2 : 1994 The following classification refers to a set of broad descriptions for classifying treatability based upon general observations associated with the use of penetrating treatment processes.

<table>
<thead>
<tr>
<th></th>
<th>Heartwood</th>
<th>Sapwood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>class 4 Extremely difficult to treat</td>
<td>class 2 Moderately easy to treat</td>
</tr>
</tbody>
</table>

General

See comments for red oak

American tulipwood *Liriodendron tulipifera*

EN 350-2 : 1994 American tulipwood has not yet been appraised for inclusion. Therefore the following classifications for durability and treatability are based upon practical experience.

Natural Durability To Wood-Destroying Fungi

<table>
<thead>
<tr>
<th></th>
<th>Heartwood</th>
<th>Sapwood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>class 5 not durable</td>
<td>class 5 not durable</td>
</tr>
</tbody>
</table>

EN 942 : 1996 Based upon the above durability classification the natural durability is deemed insufficient for exterior applications.

American tulipwood can, in practice, be used externally if the correct design, detailing and construction techniques have been adopted, along with an effective preservative pre-treatment. To maintain the protective coating “envelope”, an on-going maintenance programme is recommended.

EN 335-2 : 1992 Cross reference to ascertain the relevant hazard class.

Moisture Movement

EN 942 : 1996 Classed as medium.

Treatability

<table>
<thead>
<tr>
<th></th>
<th>Heartwood</th>
<th>Sapwood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>class 2 Moderately easy to treat</td>
<td>class 1 Easy to treat</td>
</tr>
</tbody>
</table>

The above classification refers to a set of broad descriptions for classifying treatability based upon general observations associated with the use of penetrating treatment processes.

Section prepared by Akzo Nobel Woodcare (UK).
References and further reading

Alden H.A. 1995  Hardwoods of North America
Corkhill T. 1979  A Glossary of Wood
Lincoln W.A. 1986  World Woods in Colour
AHEC 1993  Temperate Hardwoods of the USA
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European standards

EN 335-2 : 1992  Hazard classes of wood and wood-based products against biological attack.
   Part 2.  Guide to the application of hazard classes to solid wood.
   Part 2.  Guide to natural durability and treatability of selected wood species of
   importance in Europe.
EN 927-1 : 1996  Paint and varnishes – Coating materials and coating systems for exterior wood.
EN 338 : 1995  Structural timber – strength classes
EN 408 : 1995  Timber structures. Structural timber and glued laminated timber. Determination of
   some physical and mechanical properties.

Photograph Acknowledgments

Page 2 Thielemeyer GmbH (L) • Northwest Hardwoods (R)  Page 3 Carpenters’ Award (L & Rb) • Tessa Musgrave/
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   Award (L & M)
All other photographs – AHEC.

(L) = left; (M) = middle; (Mb) = middle bottom; (R) = right; (Rt) = right top; (Rb) = right bottom.
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Fax: (412) 829-0844
www.hardwood.org

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Fax: (703) 435-2537
www.hpva.org

Lake States Lumber Association
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Fax: (901) 526-7022
www.nofma.org

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