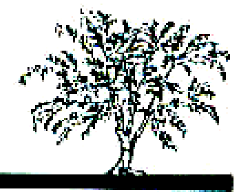
# THE MECHANICAL, PHYSICAL, AND DRYING PROPERTIES OF MESQUITE WOOD



**Ken E. Rogers**

The Forest Products Laboratory is part of the Texas Forest Service which in turn is part of the Texas A&M University System. We have been charged with increasing the proper utilization of wood in the State of Texas.

We have been investigating various uses of mesquite wood for quite a number of years. We have worked with a number of ranchers in various parts of the state. For the most part, the lab has worked at finding uses for mesquite for solid wood products.

The first part of my talk will refer to the basic physical and mechanical properties of mesquite wood. After that, I will address the proper drying procedures and a number of research studies we have completed at the laboratory.

Probably the earliest publication on the utilization of mesquite wood is THE UTILIZATION OF MESQUITE by E. D. Marshall which was published in 1945. Marshall addresses many possible uses for the wood.

Another publication, MESQUITE, by the Texas Agricultural Experiment Station is an excellent discussion of the whole mesquite question, growth, land clearing, and utlization. It is probably the most in-depth writing on this subject.

What I want to do now is talk about the basic properties of mesquite wood. Over the last few years we have completed a number of research studies on the properties of mesquite. One of the best properties of mesquite is its dimensional stability. Most mesquite craftsmen will agree that mesquite wood is very stable. If it is dried correctly it shrinks and warps very little. Tables 1 and 2 give the radial and tangential shrinkage values for mesquite compared to other hardwood species. Mesquite shrinks very little

Table 1. Comparison of shrinkage values of mesquite and selected hardwoods (dried to 0% moisture content).

| Species | Radial Shrinkage (%) | Tangential Shrinkage (%) | Volumetric Shrinkage (%) |
|---|---|---|---|
| Mesquite | 2.2 | 2.6 | 4.7 |
| White Oak | 5.3 | 9.0 | 15.8 |
| Pecan | 4.9 | 8.9 | 13.6 |

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Table 2. Select properties of several hardwood species.

| Species | Percent Shrinkage | | | Hardness | | Cleavage | Specific Gravity |
|---|---|---|---|---|---|---|---|
| | Radial | Tangential | Volumetric | End Pounds | Side Pounds | psi | |
| Beech | 5.1 | 11.0 | 16.3 | 970 | 850 | 410 | .64 |
| Sugar Maple | 4.9 | 9.5 | 14.9 | 1,850 | 1,450 | * | .56 |
| Hornbeam | 6.6 | 9.3 | 15.8 | 520 | 410 | 230 | .37 |
| Sycamore | 5.1 | 7.6 | 14.2 | 920 | 770 | 400 | .46 |
| Basswood | 6.6 | 9.3 | 15.8 | 520 | 410 | 230 | .32 |
| African Ebony | * | * | * | 1,350 | 1,780 | * | .62 |
| Mesquite | 2.2 | 2.6 | 4.7 | 2,242 | 2,336 | 259 | .70 |

1. Oven-dry weight and green-volume basis
*Information not available

and more importantly, shrinks equally in both the radial and tangential directions. So when you dry the wood you do not get excessive warpage, cupping, and twisting as you may with other hardwoods. When you have shrinkage more in one direction than the other you get different tensions built up in the wood fibers and the wood just pulls out of proportion. With mesquite you do not have this to the extent you have in most species.

Another great asset of mesquite wood is its extreme strength for uses such as flooring, tabletops, and other uses where hardness is important. It is very attractive for its strength when compared to other species. This can be seen in Table 3.

Specific gravity is basically the density of the wood. Mesquite wood's density is greater than hickories. Probably next to the ebonies, it is the most dense wood there is in the U.S. This is attributed to the weight and cellular structure.

Mesquite is about twice as hard as hickory or white oak. Being twice as hard as hickory, it makes good flooring and tabletops. Hardness is the wood's ability to withstand abrasion and scratching.

Brittleness or cleavage ability is a wood's ability to withstand being split apart. Mesquite's brittleness is approximately one-half that of the oaks and other dense hardwood species. This shows us that although mesquite is extremely hard, it is also very brittle. I have heard in a number of references today that mesquite breaks and splits very easily. This is why you use hickory for ball bats and not mesquite. Table 4 shows that mesquite is probably the best wood available for many uses; as good or better than many of the common hardwoods, such as pecan, hickory, or oak.

## QUESTIONS

Q. How does mesquite compare in hardness to maple?

A. Knowing the properties of wood, most strength properties are directly related to the specific gravity or density of the wood. Maple has a density of about two-thirds that of mesquite. Being less dense, you would expect hardness of maple to be somewhat less than mesquite.

Q. How do you best dry mesquite?

A. Three years ago we did a number of drying tests to see what were the best techniques to dry mesquite wood. We went to Brownwood and collected 25 mesquite logs and cut them at our sawmill in Lufkin. We then dried them under 5 different drying schedules, each more severe than the last. One, we just put the wood into an oven and dried it for 24 hours. This was our maximum severity schedule. Results of this study can be found in Publication 113, MOISTURE RELATIONS OF MESQUITE WOOD, of the Texas Forest Products Laboratory (seen in appendix). The study showed that mesquite can be dried under the most extreme of conditions with only minor problems.

Table 3. Strength properties of mesquite.

| | | 65 | (%) 10 | UNITS |
|---|---|---|---|---|
| | Fiber stress at proportional limit | 6,214 | 8,765 | p.s.i. |
| Static bending | Modulus of rupture | 11,700 | 15,954 | p.s.i. |
| | Modulus of elasticity | 1,141,419 | 1,380,956 | p.s.i. |
| Compression parallel to grain | Maximum crushing strength | 6,266 | 8,216 | p.s.i. |
| Compression perpendicular to grain | Fiber stress at proportional limit | 2,799 | 3,356 | p.s.i. |
| Shear parallel to grain | Maximum shearing strength | 1,387 | 2,618 | p.s.i. |
| Tension perpendicular to grain | Maximum tensile strength | — | 703 | p.s.i. |
| Cleavage | Maximum cleavage stress | 146 | 259 | lbs./inch |
| End hardness | Load required to embed a 0.444 inch ball to ½ its diameter | 2,242 | 2,336 | lbs. |
| Side hardness | Load required to embed a 0.444 inch ball to ½ its diameter | 2,132 | 2,354 | lbs. |

Table 4. Comparative strength values of mesquite.

| Wood Property | Actual Values for Green Mesquite | Published Values for Bitternut Hickory | Published Values for White Oak | Change per 1% Change in R.C. Below F.S.P. (%) |
|---|---|---|---|---|
| Specific gravity | .701 | .6 | .6 | |
| Moisture content (%) | 65 | 66 | 68 | |
| Cleavage (psi) | 146 | — | — | |
| Shear parallel (psi) | 1,387 | 1,240 | 1,250 | 3 |
| Compression perpendicular (psi) | 2,799 | 990 | 830 | 5.5 |
| Compression parallel (psi) | 6,266 | 4,570 | 3,560 | 6 |
| Hardness | | | | |
| End (lbs.) | 2,242 | — | — | 4 |
| Radial (lbs.) | 2,263 | — | 1,060 | 2.5 |
| Tangential (lbs.) | 2,000 | — | 1,120 | 2.5 |
| Static Bending | | | | |
| MOR (psi) | 11,100 | 10,300 | 8,300 | |
| MOE (psi) | 1,141,419 | 1,400,000 | 1,250,000 | |

## Appendix

## Drying 4/4 Mesquite

### Materials and Methods

Twenty-five logs, 4 to 6 feet long, and ranging from 5 to 17 inches in diameter were obtained from Brown County, Texas. The logs were stored under water spray, and reduced to 4/4, random width, 4-foot lumber as needed, on a small sawmill.

An attempt was made to divide the logs so that the board footage would be about the same in each drying run. This proved very difficult, however, since it was found that the larger logs had a greater proportion of heart rot and splits, which ran both radially and circumferentially through the logs. The number of such splits appeared to increase toward the middle, so that often only the boards taken from near the bark were salvageable. Logs up to 10 inches in diameter were of relatively high quality throughout. Batches 1 to 4 contained, respectively, 61.9, 72.0, 46.9, and 38.4 board feet of lumber.

Since most of the boards rated below any National Hardwood Standard grading classification, a grading scheme was devised in which the product sought was a board

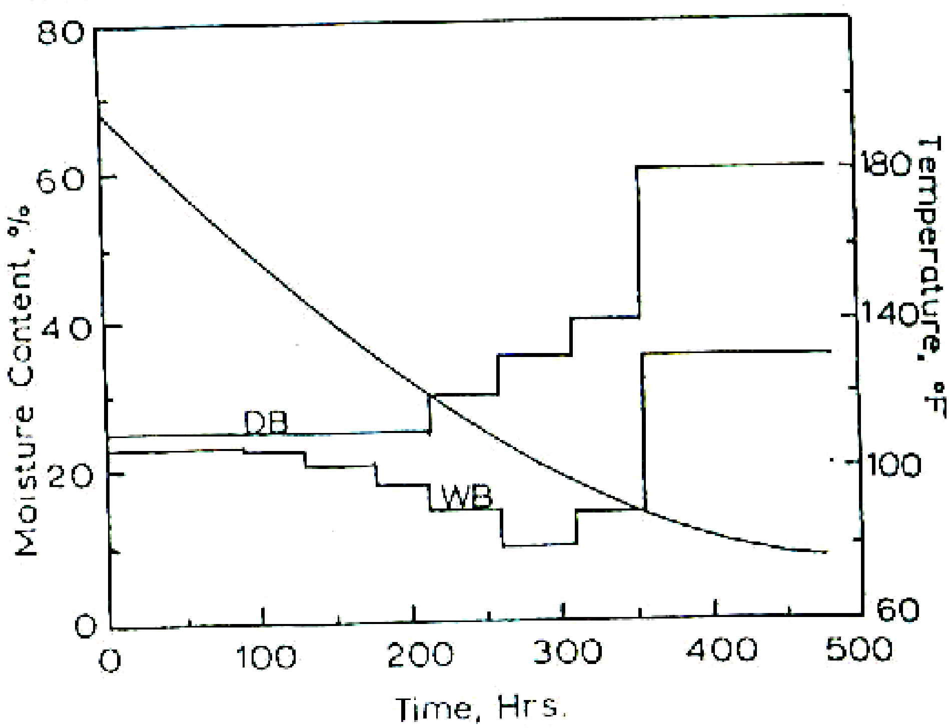


Figure 1. Dry bulb (DB) and wet bulb (WB) temperatures and moisture content of charge as functions of time for batch 1.

from which novelty items could be cut. The minimum clear cutting area was 24 square inches, with a minimum width of 1½ inches. No splits, checks, rot, or wane was allowed within a clear cutting. Worm holes and tight knots were allowed if they appeared on one side only. Boards with less than 20% of the surface area included in the cuttings were discarded.

Clear cuttings were marked off prior to drying. The percentage of area included in clear cuttings, and the number of cuttings required was recorded for each board before and after drying. The boards were then planed just enough to remove the saw marks and regraded.

Degrade was taken as the average decrease in cutting percentage. Since it is desirable that a minimum number of cuttings make up a given percentage, the average increase in cutting number was taken as a secondary indication of degrade.

Batches 1 to 3 were subjected to kiln schedules of increasing severity, the conditions of which are summarized in Figures 1 to 3. Drying was stopped when the average moisture content of the charge had reached 15%. The batch was then kiln dried under conditions of 170°F dry bulb and 100°F wet bulb temperature to bring the moisture content down to 6%. A fifth batch, containing 7 boards, was dried in an oven at 220°F.

An analysis of variance was carried out on the percentage degrade values of batches 1 to 4 to find out if any of the schedules were preferable in this regard.

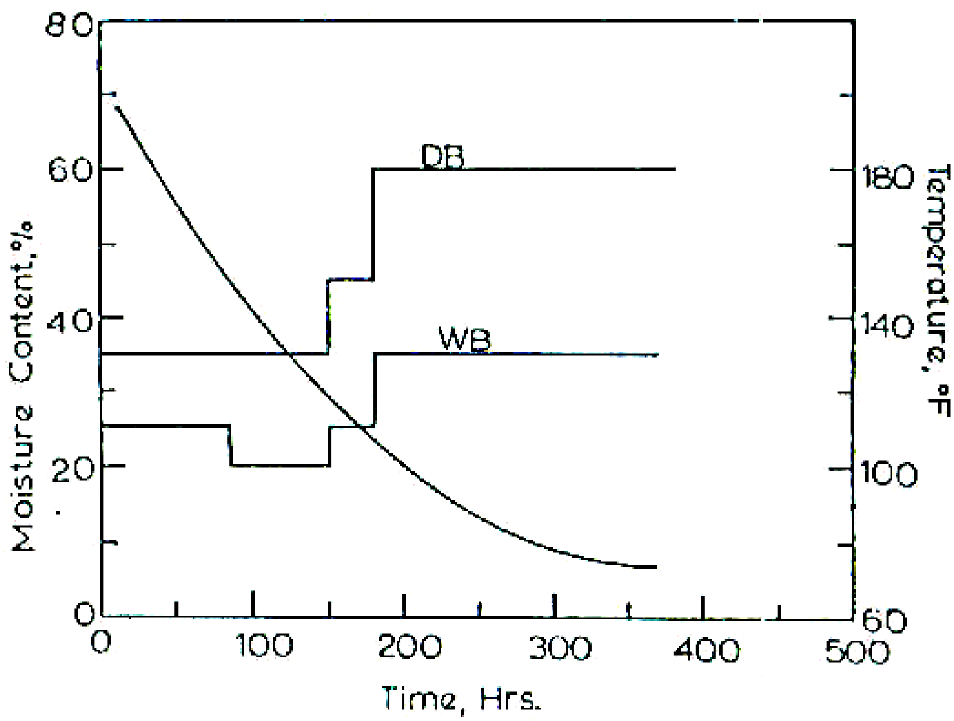


Figure 2. Dry bulb (DB) and wet bulb (WB) temperatures and moisture content of charge as functions of time for batch 2.

## Results and Discussion

Summaries of the 3 kiln drying runs are given in Figures 1 to 3. Cutting percent, cutting number, and degrade for batches 1 to 5 are given in Table 5. Total drying times for the 3 schedules were 20, 15, and 10 days. As can be seen in Table 1, degrade was slight by all 3 schedules, and there was no apparent increase in degrade with increasing severity of schedule.

There is only one reference to drying of mesquite in the literature (Marshall 1945). It was reported that air drying of mesquite was a "long and tedious process," that samples which had been air dried for 1 year began to check immediately when placed in a drying oven with only a slight rise in temperature. Batch 4 was air dried in order to test this statement. Air drying proved to be as satisfactory as kiln drying.

Analysis of variance summaries are given for batches 1 to 4, for conditions before (Table 6) and after (Table 7) planing. Treatments were the drying methods, while observations were the percentage degrade for each board. The analysis confirmed that there was no difference between drying methods in this regard. The reason that the mean square error is larger after planing than before is that planing often revealed splits that were not visible before planing, in addition to removing some surface checks. Also, since the clear cutting lines were removed during planing, greater experimental error

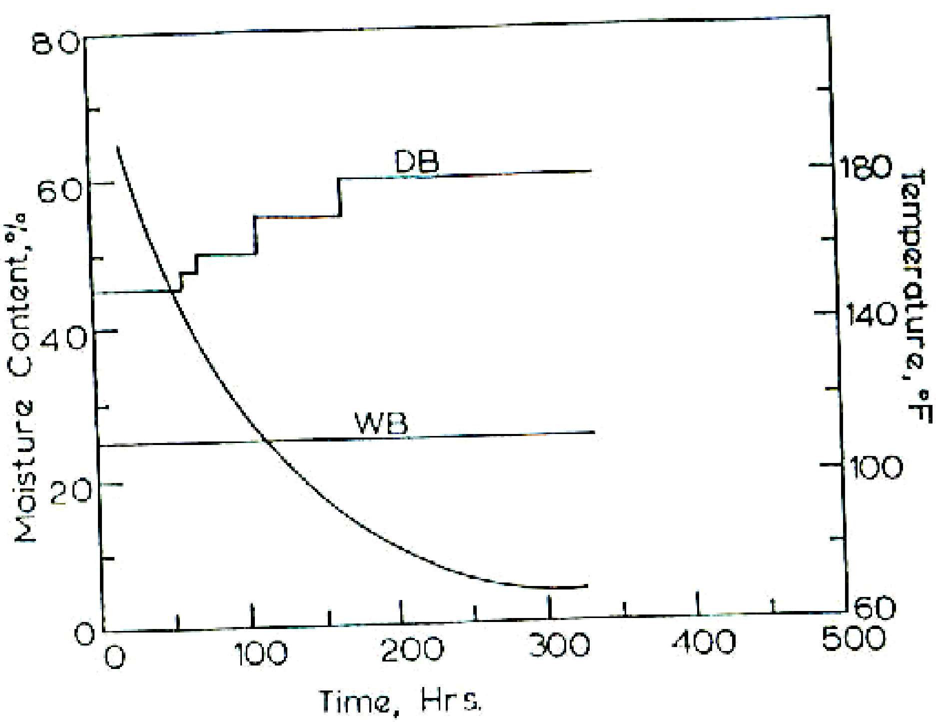


Figure 3. Dry bulb (DB) and wet bulb (WB) temperatures and moisture content of charge as functions of time for batch 3.

Table 5. Cutting percentages and number before drying and drying degrade measured before and after planing. Positive sign indicates an increase, while negative sign indicates a decrease.

| | Cuttings Before Drying | | Degrade | | | |
|---|---|---|---|---|---|---|
| | | | Before Planing | | After Planing | |
| Batch | Percent | Number | Percent | Number | Percent | Number |
| 1 | 61.2 | 1.6 | −4.4 | ±0.2 | −5.2 | 0.0 |
| 2 | 63.2 | 1.8 | −2.3 | 0.0 | −2.5 | ±0.1 |
| 3 | 57.4 | 2.2 | −5.7 | ±0.1 | −6.3 | ±0.1 |
| 4 | 57.2 | 1.8 | −3.9 | ±0.1 | −5.3 | ±0.1 |
| 5 | 49.8 | 1.1 | −7.7 | ±0.1 | — | — |

Table 6. Summary of analysis of variance of degradation of mesquite wood after drying but before planing.

| Source | Degrees of Freedom | Sum of Square | Mean Square | F |
|---|---|---|---|---|
| Among | 3 | 11 | 3.67 | .04 |
| Within | 100 | 9,209 | 92.09 | |
| Total | 103 | 9,220 | | |

Table 7. Summary of analysis of variance of degradation of mesquite wood after drying and planing.

| Source | Degrees of Freedom | Sum of Square | Mean Square | F |
|---|---|---|---|---|
| Among | 3 | 122 | 40.6 | .978 |
| Within | 100 | 4,154 | 41.5 | |
| Total | 103 | 4,276 | | |

was encountered in trying to reassess the maximum cutting percent.

The purpose of drying batch 5 so quickly was to attempt to find a drying rate which would cause profuse checking. Large checks were found in the sapwood, but little checking occurred in heartwood.

Some remarks are in order regarding other aspects of drying degrade. There was no cupping observed in any of the batches. Bow, crook, and twist were significant and the severity appeared to increase with severity of drying schedule. A color change, from greyish brown to various shades of pink, frequently occurred, and the depth of change appeared to increase with severity of schedule. No instance of honeycombing was observed, and collapse occurred only in batch 5. Case hardening was slight to moderate in all batches.

Absence of cupping, checking, and honeycomb is probably related to the high dimensional stability of mesquite. Total radial and tangential shrinkages are 2.2 and 2.6%, respectively (2).

The large amount of checking which occurred in the sapwood of batch 5 was proposed to be due to greater shrinkage in the sapwood than in heartwood. In order to test this hypothesis, 36 green sapwood specimens were cut for total shrinkage determination. Of these, 12 specimens were from just inside the bark, 12 were from just outside the heartwood, and 12 were from approximately midway between the bark and the heartwood. Shrinkage was determined in the tangential direction. Specimens from the bark-side shrank an average of 5.0%, those midway between bark and heartwood shrank an average of 4.2%, while those adjacent to heartwood shrank an average of 3.6%, indicating decreasing shrinkage in the direction away from the bark. Shrinkages were significantly different at the 95% level. Since previous studies indicated tangential heartwood shrinkage of 3.2 and 2.6%, the data appears to support the hypothesis.

The high degree of bow, crook, and twist which occurred in all batches is due to the large amount of cross grain inherent in the bent, twisted logs from which boards are taken. This could be a serious hinderance to use of the wood in furniture, but this type of warpage may be kept to a minimum by air drying. Application of kiln weights might help prevent warpage during kiln drying.