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Moisture Content of Wood for Interior Use . . .

Douglas-fir and robusta eucalyptus samples studied

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ABSTRACT: Panels of Douglas-fir and robusta eucalyptus blocks showed little seasonal variation in Equilibrium Moisture Content (EMC) of wood at 19 indoor locations on Oahu, Hawaii. Differences in EMC between locations were more variable. Minimum EMC at nonair-conditioned locations was 10 percent; at air-conditioned locations, 8 percent. Maximum EMC at nonair-conditioned locations was 16 percent; at air-conditioned locations, 12 percent.

OXFORD: 174.7 *Pseudotsuga menziesii* (969): 812.213--015.28 + 176.1 *Eucalyptus robusta* (969):812.213--015.28

RETRIEVAL TERMS: *Pseudotsuga menziesii/menziesii; Eucalyptus robusta;* Hawaii; moisture content; equilibrium moisture content; seasonal variation; air conditioning; indoor locations.

Manufacturers and users of wood know that wood shrinks and swells as its moisture content changes. But they usually assume that seasonal change in moisture content is slight at a given location. In a study of wood samples inside some structures on Oahu, Hawaii, we found enough differences in moisture content in different locations to call attention to the problem. The two species tested were Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*), a commonly used softwood, and robusta eucalyptus (*Eucalyptus robusta*), a dense hardwood.

Generally wood of higher density tends to gain or lose moisture more slowly than wood of low density. And wood of higher density tends to shrink or swell more with moisture changes than wood of low density.

To the wood-user, this characteristic of wood to change as moisture content changes poses one of the most serious and least controllable problems. Some chemical processes can stabilize the wood, but they are costly. Their use is usually restricted to small items of high value, such as gun stocks and wood carvings.

A more practical method--the one recommended--is to put wood into service at about the mean of the range of moisture content expected during use. This note reports the range of moisture content for Douglas-fir and robusta samples determined indoors at 19 locations on Oahu, Hawaii.

Materials and Methods

We placed test panels of wood samples in buildings at places representing a wide range of climatic conditions. Some of the buildings, including houses, had air-conditioning; some did not. Insofar as possible, the samples were located where large residential concentrations exist or are developing. Air-conditioned offices were included to give some indication of wood moisture content to be expected in wood furniture and paneling.

Each test panel consisted of five samples of Douglas-fir and five of robusta eucalyptus mounted on a 16- by 16-inch pre-finished plywood backing. The specimens were about 7/8-inch by 1-1/2-inch by 5 inches. They were attached to the plywood in two rows of five each, using "hooks and eyes" (fig. 1). This method permitted easy removal for weighing. Each matched test panel included specimens randomly selected from five different boards of each species, and thus provided some range within species included. The specimens were all heartwood, surfaced, and not painted.

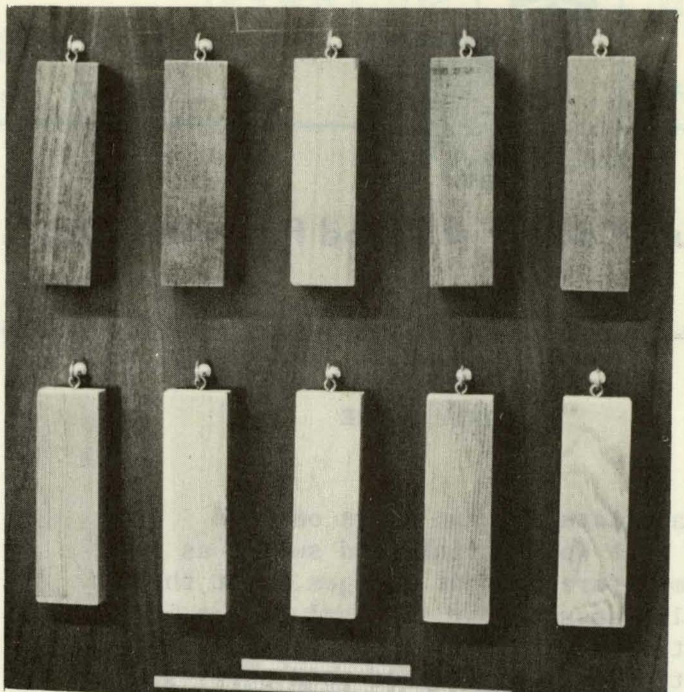

Figure 1.--*Test panels consisted of five blocks each of Douglas-fir and robusta eucalyptus. They were placed inside selected homes and buildings and their moisture content checked during a 12-month period.*

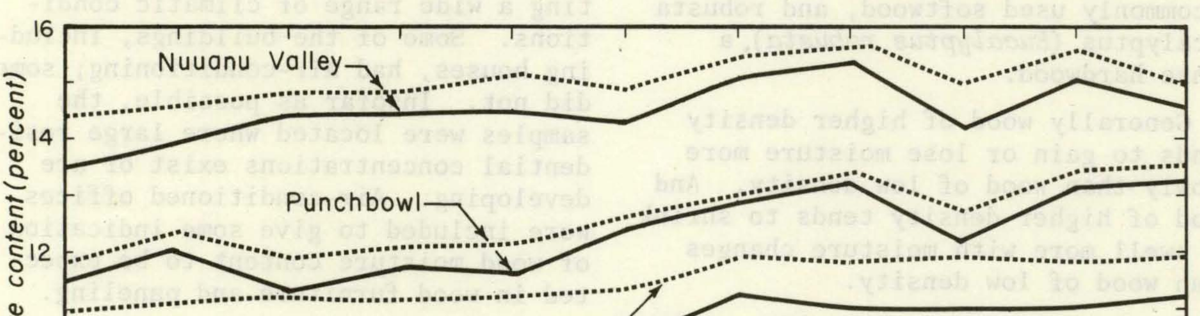

Figure 2.--*Monthly fluctuations in moisture content of wood samples at selected sites. Solid line (——) represents Douglas-fir. Broken line (---) represents robusta.*

Test panels were attached to a room partition or interior wall at about eye level. They were placed so that they would receive good ventilation and not be subjected to direct sunlight or rain. Rooms with frequent high relative humidities, such as kitchens and bathrooms, were not used. The samples were weighed before each installation.

For 12 months, as regularly as possible at 4-week intervals, I weighed each sample to 0.1 gram on a triple beam balance. The same balance was used for all weighing to assure comparability. At the end of the year, I oven-dried all the sample blocks, and calculated the moisture content of each block at the time of monthly weighing to the nearest 0.1 percent. The average moisture content of each species was calculated at the time of monthly weighing. Using these data, I determined a range of average Equilibrium Moisture Content (EMC) for each of the two species of wood at each location (table 1).

Results and Discussion

The seasonal or monthly change in moisture content was only 1 to 3 percent at each site. Monthly fluctuation at a few selected locations (fig. 2) showed more variation between locations than monthly variation at any one location.

The minimum EMC at nonair-conditioned locations was 10 percent; and at air-conditioned locations, 8 percent. The maximum EMC at nonair-conditioned locations was 16 percent; and at air-conditioned locations was 12 percent. In nonair-conditioned exposure, EMC of robusta eucalyptus remained about 1 percent higher than that of the Douglas-fir, except at one location and in three monthly weighings at two other locations. In two of the three air-conditioned locations, the robusta sample had a lower EMC than the Douglas-fir sample. Also in the air-conditioned locations there was less difference in EMC between the two species. These variations suggest that robusta, a dense wood with a lower hygroscopicity, tends to react less rapidly to changes in moisture content than Douglas-fir.

In the continental United States, moisture content of interior woodwork may fluctuate 6 to 7 percent during seasonal changes, except in the arid Southwest, where fluctuation is only about 3 percent.[1] Residences in the continental United States have heated interiors for several months of the year. Heating lowers the EMC of the interior woodwork of the house. Houses in Hawaii have no heating systems, although some residences at the higher elevations have fireplaces which may be used on chilly evenings. Therefore, the EMC of interior wood in Hawaii is not generally influenced by artificial heat but is influenced by air-conditioning. Air-conditioning was much more common in business offices than in residential areas at the time of the study.

Conclusions and Recommendations

1. We found little seasonal variation in the moisture content of wood at a given site. In Hawaii, as elsewhere, we recommend that wood be placed into service at approximately the mean of the range of moisture content expected during use (table 1). The problems of shrinking and swelling should be minimal. We know, for example, that furniture manufactured in Hilo, where the EMC is about 15-16 percent, behaves quite well there. But if the furniture is then brought to Honolulu and placed in an air-conditioned office with an EMC of 8 to 9 percent, joints and seams will open up.

Wood flooring should be laid when its moisture content is within the EMC of the area. Flooring laid when it is too wet will shrink in place and may show cracks between the boards, or the tongue may be visible in the cracks.

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[1]Peck, E. C. *Moisture content of wood in use.* U. S. Forest Serv. Forest Prod. Lab. Rep. 1655. 10 pp. (Revised) 1955.

Table 1.--*Average Equilibrium Moisture Content (EMC) of Douglas-fir and robusta eucalyptus wood samples and mean annual rainfall, at specified locations, Oahu, Hawaii*

Location	Air-conditioned	EMC range[1]		Mean annual rainfall[2]
		Douglas-fir	Robusta	
		Percent		*Inches*
Ewa Beach (on water's edge)	No	11-13	12-14	17
Diamond Head (on water's edge)	No	11-13	12-14	20
Kalihi-Kai	Yes	10-11	10-11	27
Kalihi-Kai	No	10-12	11-13	27
Downtown Honolulu (Beretania & Miller Sts.)	No	11-13	11-13	32
Downtown Honolulu (Beretania & Miller Sts.)	Yes	8-9	8-9	32
1633 Kapiolani Blvd.	No	10-11	10-11	37
Kailua (Pamaele Street)	No	12-13	12-13	37
Kailua (Mahealani Pl.)	No	12-13	13-14	37
Pacific Palisades (Akaikai Loop)	No	10-11	11-12	37
Punchbowl	No	10-11	11-12	37
University of Hawaii (Manoa Campus)	No	11-12	10-11	40
University of Hawaii (Manoa Campus)	Yes	10-12	11-12	40
Waimanalo Agr. Exp. Farm	No	12-13	12-14	45
Wahiawa (Calif. Ave.)	No	12-14	12-14	50
Kaneohe (Akimala Pl.)	No	13-14	13-14	63
Makiki (Makiki Hts. Dr.)	No	11-14	11-14	67
St. Louis Hts. (Quincy Pl.)	No	11-13	12-13	65
Nuuanu Valley	No	14-15	14-16	115

[1] Blocks had all been in a similar environment for at least a month before installing; therefore, the EMC calculated from the weights at the time of installation was omitted from the range.

[2] Taliaferro, W. J. *Rainfall of the Hawaiian Islands*. State of Hawaii, Hawaii Water Authority, Honolulu. pp. 259-339. 1959.

If it is laid when too dry, and adequate room is not left for expansion between boards, the floor will buckle when its moisture content reaches the EMC for the site. If there is a substantial difference in moisture content between the veneer and the core material in veneered furniture, the veneer may split or develop "bubbles" when the core and veneer come to equilibrium moisture content depending on whether the veneer was wetter or drier than the core at the time of assembly. Similar problems may occur with cabinets if the wood is not near the EMC--doors may stick or the joints may open.

2. The difference in EMC between locations is large enough to merit attention (table 1). This condition is particularly apparent when lumber or wood products have been stored in areas where the EMC may be as low as 10 percent and then installed in areas where the EMC may be as high as 16 percent.

A common practice is to store flooring under the roof of a house being built so that it will reach EMC before laying. But this practice is effective only if the flooring strips are separated by stickers. Air must reach the lumber to moisten or dry it.

3. When it is known at time of manufacture or assembly that wood products are to be used in air-conditioned environments, dry the wood to a moisture content 2 to 3 percent lower than wood used in nonair-conditioned environments. Except for the outside boards, the lumber can be held at this lower moisture content for several weeks if kept close piled and under cover.

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