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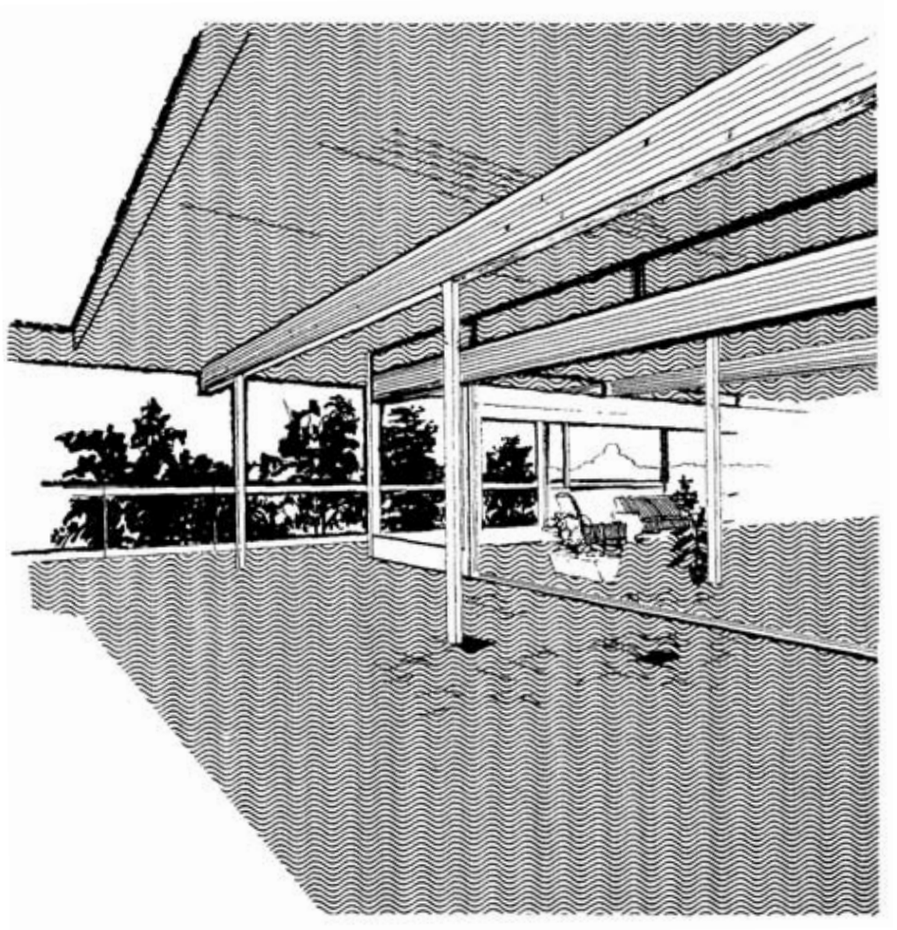
MOISTURE CONTENT OF LAMINATED TIMBERS



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Abstract

The moisture content of laminated timbers in four climates of the United States and various use situations was measured quarterly over a 3-year period. The year-round national average moisture content for protected exterior exposure was 9 percent; for interior exposure, 8 percent. Unprotected exterior exposures and such special interior environments as swimming pools exhibited wide variations in moisture con-'tent. Designs to prevent wetting at joints and ends and to provide proper ventilation were effective in reducing the moisture content of timbers in these exposures.

MOISTURE CONTENT OF LAMINATED TIMBERS

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Introduction

Laminated timbers are among the most efficient and impressive examples of the modern forest products industry. The development of the laminated timber industry has provided the architect with the opportunity to choose from a wide variety of structural forms and sizes and to design with both appearance and economy in mind. The research described in this report was carried out by the Forest Service in cooperation with the members of the American Institute of Timber Construction and the owners or managers of approximately 80 structures to answer the question, "What is the most likely moisture content of a laminated timber when used in a specific climate and structure?"

This question is important because the wood used in these timbers, as in all wood products, assumes a moisture content that is in approximate equilibrium with the surrounding environment. Therefore, the ideal moisture content at the time of fabrication is the moisture content that it will attain in the structure. This minimizes unsightly checking and changes in dimension.

Research on the question of the proper moisture content for wood products has been carried out for over 50 years. However, this research has been focused on lumber and furniture items that are much smaller in cross section than a typical laminated timber, so they respond quickly to daily, weekly, and seasonal variations in the relative humidity of the air. Therefore, these past results are not directly applicable to laminated timbers. Furthermore, such members are often partly inside and partly outside the structure, so one end may be exposed to exterior climatic conditions and the other end exposed to interior environments.

This report deals with geographical and seasonal variations in the moisture content of laminated timbers used in various types of structures. The general nationwide results of the study are emphasized. Each of the

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cooperating Experiment Stations is planning to prepare a detailed report on results obtained in its respective climate.

Procedure

The first steps necessary to carry out this study were to locate representative laminated-timber structures in various climates, to obtain permission of the owners to study the structures and to develop effective procedures for measuring the moisture content at various times.

The climates selected represent a broad sample of the climates or regions of the continental United States. The Southeastern Forest Experiment Station studied structures in and near Athens, Ga. The Forest Products Laboratory. studied structures in and near Madison, Wis. The Rocky Mountain Forest and Range Experiment Station studied structures in several locations ranging from South Dakota to Arizona and New Mexico. The Pacific Northwest Forest and Range Experiment Station studied structures in western Washington and Oregon. Thus, regions included dry, wet, warm, and cold areas. In this report regions are referred to as Southeast, Lake States, Rocky Mountain, and Pacific Northwest.

The structures were selected by scientists from each of the Forest Service research units involved in this study, often with the assistance of members of the American Institute of Timber Construction. An effort was made to select structures that represented a broad range of use conditions. Some examples are churches, schools, swimming pool enclosures, food processing plants, bridges, sign structures, and bank buildings.

The next step was to contact building owners to obtain permission to measure moisture contents over a period of 3 years. After it was explained to each owner that the study would not damage the beam or create an unsightly appearance, the response was universally favorable and no difficulty was experienced in obtaining permission.

The procedures used for measuring moisture contents were based on the wood moisture probe developed by Duff.[5] This probe was selected because it is small and can be inserted in a beam at any depth by simply drilling a small hole. Furthermore, lead wires from the probe can be run to a location that is readily accessible. This made it unnecessary to carry ladders to the site for each moisture reading. Another advantage of moisture probes as compared to a resistance moisture meter with conventional needles is that new holes are not necessary each time a moisture reading is obtained. This is especially important in locations where appearance is a prime consideration.

Probe Installation

Approximately 1,000 moisture probes were fabricated at the Forest Products Laboratory. These were then divided into four lots and supplied to the Forest Service scientists at each location for installation in the selected members. The location and number of probes installed in each timber and each structure varied widely depending on the type of structure. In all cases, however, an effort was made to insure that probes were installed in areas susceptible to the full range of moisture conditions common to exposure. For example, in a timber that was fastened into steel shoes in an exterior location and extended through a wall to a roofline on the inside of a structure, probes would be placed near the shoe and at various locations both inside and outside of the structure so that the maximum variation in moisture content would be observed. Probes were generally placed at midthickness of the timber and at least three-quarters of an inch from any face in order to remove any transient surface effects. The installation procedures used by the Pacific Northwest Station, as described by Oviatt,[6] are representative of those used in the entire study. After the probes were installed, the moisture content readings were taken on a quarterly

[5]Duff, J.E., 1966. A probe for accurate determination of moisture content of wood products in use. U.S. Forest Serv. Res. Note FPL-0142. Forest Products Lab., Madison, Wisconsin

[6]Oviatt, A.E., Jr., 1968. Moisture content of glulam timbers in use in the Pacific Northwest. Pacific Northwest Forest & Range Exp. Sta, Forest Serv., USDA, Portland, Oreg.

basis over a 3-year period. In some cases, the readings were more frequent; in a few structures, the readings were terminated at an earlier date. The data analyzed for this report were obtained on the quarterly basis over a period of at least 2-1/2 years.

Summary of Results

Based on data collected, average seasonal interior moisture contents for laminated timbers ranged from 6.4 percent moisture content during the summer in the Rocky Mountain region to 9.0 percent during the summer and fall in the Southeast. In exterior exposure protected from direct rain, the average values ranged from 6.7 percent in the Rocky Mountain region in summer to 11.8 percent in the Pacific Northwest in winter. The values for different regions, seasons, and types of exposure are summarized in table 1. The year-round national average moisture content for exterior protected exposure was 9 percent, and the year-round national average for interior exposure was 8 percent. The Rocky Mountain region was slightly drier than the other three regions but seasonal or geographic variation for both of these exposures was quite narrow, table 2. The average values can be used as a good estimate of the moisture content that a laminated timber will reach in the type of exposure.

For unprotected exterior exposure and special interior environments, such as ice skating rinks, swimming pools, and freezer plants, the average is not useful because of wide extreme above the median by individual structures. In such exposure, therefore, the most frequently observed moisture content or mode is the more useful value. These are given in table 3. Designs that will prevent the extremes such as wetting by rain or condensation are of great concern in members used in exterior unprotected and special environments.

Table 1. — Average Seasonal Moisture Contents for Laminated Members In —

Region	Season			
	Winter	Spring	Summer	Fall
	Pct.	Pct.	Pct.	Pct.
Lake States	7.8	7.8	7.5	7.9
Pacific Northwest	7.3	7.0	7.4	8.2
Rocky Mountain	6.6	6.7	6.4	6.7
Southeast	8.3	8.8	9.0	9.0
Lake States	10.4	10.0	9.6	9.9
Pacific Northwest	11.8	10.3	9.9	10.0
Rocky Mountain	7.6	7.2	6.7	6.9
Southeast	10.2	10.2	10.0	10.3
Lake States	13.5	12.4	10.5	11.5
Pacific Northwest	26.8	21.7	14.0	19.8
Rocky Mountain	11.0	11.2	11.0	9.2
Southeast	13.6	13.6	13.5	13.1
Lake States	19.9	17.4	18.2	20.3
Pacific Northwest	13.8	12.7	13.8	14.2
Rocky Mountain	9.1	9.4	8.6	9.9
Southeast	–	–	–	–

Analysis and Discussion

The moisture content readings obtained in this study were corrected for temperature and recorded on large data sheets. After all the data had been obtained, the results and pertinent structural and climatic information for each structure were placed on punchcards so that various comparisons could be easily made. The most useful system of analysis was devised by Oviatt.[6] He defined four exposure conditions for a timber or portion of a timber. These conditions are (1) interior normal occupancy; (2) exterior protected; (3) exterior exposed; and (4) special occupancy.

Interior normal exposures are those found in enclosed heated and ventilated buildings. Schools and churches are typical examples. Exterior protected members are those that

Table 2. — Number of readings (N) and standard deviation of readings about the mean (γ) for each region, season, and exposure condition

Region	Number of structures	Season							
		Winter		Spring		Summer		Fall	
		N	γ	N	γ	N	γ	N	γ
Lake States	14	208	.92	55	.75	128	.65	225	.79
Pacific Northwest	4	84	.69	28	.51	84	.77	28	.75
Rocky Mountain	22	264	.73	176	.76	176	.85	264	.84
Southeast	6	78	1.76	44	.86	58	1.03	60	1.25
Lake States	7	71	1.49	24	1.88	48	1.88	70	1.50
Pacific Northwest	1	12	1.08	4	.50	12	1.09	4	0
Rocky Mountain	20	230	1.24	156	.88	156	1.31	229	.94
Southeast	6	118	1.81	75	.92	107	.62	105	1.54
EXTERIOR UNPROTECTED EXPOSURE									
Lake States	6	67	9.71	23	2.82	46	2.27	65	2.42
Pacific Northwest	6	148	18.92	52	15.30	124	8.21	80	15.62
Rocky Mountain	4	5	2.34	4	5.44	4	3.65	6	1.94
Southeast	1	60	5.59	39	4.72	57	4.56	53	3.38
Lake States	1	33	13.08	11	10.28	22	15.88	33	15.62
Pacific Northwest	8	89	4.88	32	3.67	92	4.91	35	4.78
Rocky Mountain	2	32	.92	23	1.48	24	1.38	35	1.53
Southeast	--	--	--	--	--	--	--	--	--

are effectively protected from rain and sun but are exposed to normal exterior variations in temperature and relative humidity; beams in a carport would be a typical example. Exterior exposed members are subject to all of the rainfall, sunlight, temperature and humidity variations that occur outside. Laminated transmission towers, crossarms, and light risers are typical examples. Special occupancy conditions include those found in such structures as swimming pool enclosures, skating rinks, freezer plants, and food-processing buildings.

These four exposure classes were selected primarily because of the ease with which architects and builders could identify them, so that the results of the study would be useful to prospective designers and builders of laminated structures.

The data were listed by geographic region and exposure condition for each quarter of the 3 study years. This separation was not difficult—a point in favor of the four exposure classes used. The results were then summarized in various ways in an effort to find the most simple and meaningful way of showing the data. The results believed most useful are presented in the summary of results and tables 1 and 3.

Table 3. — Mode, maximum, and minimum observed moisture content in various regions for all seasons

Region	Moisture Content		
	Mode	Maximum	Minimum
	Pct.	Pct.	Pct.
EXTERIOR UNPROTECTED EXPOSURE			
Lake States	11	65	7
Pacific Northwest	13	65	5
Rocky Mountain	10	19	6
Southeast	12	29	8
SPECIAL EXPOSURE			
Lake States	14	65	7
Pacific Northwest	14	35	8
Rocky Mountain	9	11	7
Southeast	--	--	--

Interior Normal Exposure

There was remarkably little geographic or seasonal variation in the moisture content of laminated timbers in interior normal exposure. Also, the variation in reading within and between timbers was quite small. It appears that modern heating and ventilating systems tend to even out variations in moisture content due to climate and season of the year, and heavy sections respond slowly to changes. These results simplify the problem of specifying and fabricating members for this exposure condition. A fabrication moisture content as near to 8 percent as can be practically maintained under shipment and erection limitations is indicated.

Exterior Protected Exposure

The range in moisture contents observed in protected exterior exposures is also quite narrow. The moisture content depended primarily on the average relative humidity of the climate. This is, of course, understandable because these members are protected from rain and sunlight. As Schein[7] points out, it is important to design timbers intended for exterior exposure to insure that exposure can be truly classified as exterior protected. Protection of exposed end-grain and connections is especially important,

Unprotected Exterior Exposure

Moisture content readings in unprotected exterior exposure were influenced by climate and design. In the Rocky Mountain region with its relatively light rainfall, the moisture content in unprotected exterior exposure was quite low and generally not highly variable. The reader should note that, even in dry climates, there is a decay hazard associated with unprotected exterior exposure so protection from decay should be provided. In the other three locations the moisture content in unprotected exterior exposure was extremely variable and depended on the design and finish of the timber. Oviatt[6] and Schein[7] discussed the problem of designing for exterior exposure very well.

Special Exposure

As one would expect, the moisture contents observed in special exposure conditions were highly variable and depended primarily on the amount of ventilation in the structure. Timbers in swimming-pool areas that were poorly ventilated showed high moisture contents. However, timbers in similar pool areas with good ventilation exhibited little more moisture content than was found in normal interior exposure.

[7]Schein, E. W., 1968. The influence of design on exposed wood in buildings of the Puget Sound Area. Pacific Northwest Forest & Range Exp. Sta., Forest Serv., USDA. Sept.