RESEARCH HIGHLIGHT

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Guidelines for On-Site Measurement of Moisture in Wood Building Materials

INTRODUCTION

In parts of the country, such as the lower mainland of British Columbia, moisture management through the design and construction techniques used in building envelopes is a critical factor in protecting the durability of wood structures. Of particular concern is construction in wet site conditions. When excess moisture is retained over sustained periods, premature failure due to decay or other physical, biological or chemical effects can occur. As wood dries, it shrinks, giving rise to such problems as:

- nail popping leading to loss in airtightness and drywall plaster popping
- differential settlement leading to drywall cracks, floor squeaks
- building height settlement leading to potential problems with plumbing.

Canada's National Building Code (NBC), and related provincial codes, specifies that lumber be "dry" at time of installation; lumber is considered to be "dry" when it has a maximum moisture content (on a dry weight basis) of 19 per cent. The equilibrium moisture content finally attained by lumber in a building may be 8 per cent or lower; depending on location in the building and climate. Whether or not lumber framing conforms to NBC requirements, shrinkage effects still need to be accounted for in construction. Problems arising from shrinkage, however, can be reduced through greater care in using wood-based building materials, including lumber, panels and other wood products.

In the past, construction practices were forgiving to higher initial moisture content and to the addition of moisture during the building process. Construction scheduling was slower, permitting gradual drying of the wood frame structure. Lumber subflooring permitted drainage of moisture that impinged on the partially completed structure and prevented ponding of water. Lumber wall sheathing, permeable to both air and vapour movement, resulted in rapid drying of excess moisture in the wall cavity.

This has changed with the use of dry rather than wet practices for interior finishes, plywood and oriented strand board (OSB) panels and power tools. Construction practices today allow for greater flexibility, ease of assembly and much shorter construction times. Faster construction is driven by the cost of money tied up in purchasing the land and materials for the building, as well as a need to keep housing as affordable as possible.

In recent years, there has been an increased interest in field measurement of moisture content in wood-based materials and in construction practices that can help minimize moisture-related problems. Canada Mortgage and Housing Corporation and the Canadian Wood Council joined together in funding Guidelines for On-Site Measurement in Wood Building Materials to assist builders, inspectors and engineers in conducting and interpreting moisture meter readings.

As field measurements are more variable and complex than measurements obtained in controlled laboratory or industrial conditions, it may still be helpful to consult experienced practitioners regarding the guidelines.

MEASURING MOISTURE CONTENT

Wood is a complex material to dry. Differences in species and natural variations in grain pattern, density and the amount of sapwood/heartwood result in a certain amount of variability in the final moisture content. For these reasons, end users must be prepared to accommodate a certain amount of variability in the final moisture content.

The two techniques commonly used by the lumber industry to assess moisture content in solid wood are the oven-dry method and electrical moisture meters.

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OVEN-DRY METHOD

The oven-dry method is generally the standard against which other methods of assessing moisture content are judged, since it is the most reliable in terms of precision and accuracy. This method requires only a small specimen for testing, but because it is destructive and time-consuming, it is generally used in laboratory studies.

Samples are cut approximately 30 to 40 cm from the end of the board and are 2 to 3 cm wide along the grain, as shown in figure 1. The samples are weighed using a balance with a capacity of 500 g and an accuracy and readability to within 0.1 g. The "wet weight" is recorded directly on the samples which are then placed in an oven pre-set at 102°C to 105°C and left for 18 to 24 hours. Towards the end of this period, one or two of the larger samples are weighed at several one-hour intervals to assure they have reached a constant dry weight.

A household microwave oven may be used, although some precautions are required. To prevent overheating and burning, the sample must be dried using several short bursts at a low power setting. Turnaround time can be reduced to about 1 hour, but using a microwave will require constant supervision.

Moisture content is calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{(\text{wet weight - dry weight})}{(\text{dry weight})} \times 100$$

ELECTRIC MOISTURE METERS

There are two general categories of moisture meters, one being DC-resistance meters and the other dielectric meters. Both are widely used in the lumber manufacturing industry; both have a working range from about 25 per cent moisture content down to approximately 5 or 6 per cent; and under good conditions, both have similar levels of accuracy. Choosing between the two depends on the type and location of the test to be conducted.

For either type of meter, a spot check on calibration should be carried out, following the manufacturer's instructions, before conducting a moisture check on a building or wall system. As well, readings should be done on clear wood. Knots, pitch pockets and incipient decay can affect the density or extractive content of the wood and alter the readings. Ions from corrosion of fasteners can also distort readings.

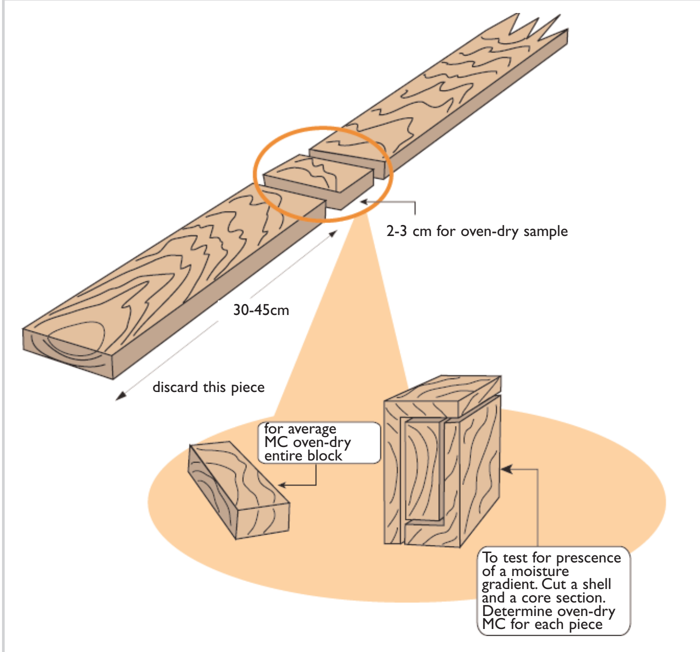

Figure 1 Preparation of specimens for oven-dry method

DC-resistance meter (Figure 2) readings are obtained by inserting a pair of pins into the wood and measuring the resistance to the flow of a DC current. It is important to remember that a given reading is only for the narrow band of wood between the tips of the pins. Moisture gradient and pinning depth and location can significantly affect the results. For example, several Canadian species are prone to a condition known as "wet pockets", which prevent the establishment of a normal moisture gradient. When testing wood that is prone to wet pockets, care must be taken to avoid obtaining misleading results. Readings from a dielectric meter will be less influenced by this condition than those using a DC-resistance meter. Guidelines for On-Site Measurement also discusses steps that must also be taken to adjust for temperature and species, two principal factors that affect the DC-resistance of wood.

Figure 2 DC-Resistance meter.

Dielectric moisture meters (Figure 3) have a sensor that is brought into direct contact with the wood being tested. They emit a radio frequency field which penetrates the wood and measure the response. Both wood density and moisture level affect the readings, and corrections are required to compensate for differences in density between the species. These meters are only minimally affected by wood temperature, but species corrections are required, which are supplied by the manufacturers. Dielectric meters are also affected by moisture gradients. They tend to be more heavily influenced by surface moisture than core moisture. For example, this type of meter will not function well for a board that may be well dried through most of its cross-section but has been re-wetted on the surface by recent exposure to moisture. In this instance, a dielectric meter will over-estimate the average moisture content. This may be a common problem at building sites where partially framed structures are exposed to rain or melting snow.

Figure 3 Dielectric Moisture Meter

Guidelines for On-Site Measurement provides further direction regarding factors to consider when sampling wood framing. These include consideration of moisture distribution, wall studs and plates, grade stamps, climatic factors, type of wall system, orientation and indoor climate. For example, the guidelines note that bottom plates are likely to be the wettest of the framing lumber and should be checked more rigorously. For vertical members, meter readings should be taken at various heights and depths to assess the average moisture content and moisture distribution.

Meters can also be used on composite products, such as plywood and OSB. For solid wood treated with preservatives or fire-retardants, however, there is limited information on how to interpret readings.

REDUCING MOISTURE PROBLEMS

Designers and builders can take steps to minimize construction complications due to moisture. Many are simple to implement, while some may be more difficult and costly.

If it is not possible to allow framing to dry prior to final closing of a structure, kiln-dried lumber should be used to permit a shorter construction schedule. This will limit warp and also eliminate any potential carry-over of fungal infection from the standing tree or log stage.

More attention should be given to protecting materials stored on site. A simple platform or series of platforms that keep materials from contact with the ground is a good practice. Some engineered wood materials cannot tolerate extended exposure to moisture or direct contact with soil and water, and they should be treated more carefully than sawn lumber. Wrapping on packaged lumber materials or materials that have been dried should be left on until the materials are needed and replaced when the materials are not needed.

Even after roof sheathing has been applied, it is still possible for moisture to enter a structure through joints between panels. If finishing a roof cannot be scheduled soon after roof sheathing is in place, then immediately installing a roofing paper membrane over the entire roof will provide the necessary protection. There is an additional advantage in this: the dark asphalt roofing paper absorbs solar energy and speeds drying by improving the convection of naturally heated air from inside the partially completed structure.

Builders who orient structural sheathing vertically, and use a moderately thicker sheathing to avoid buckling between studs, find this provides a continuous surface that can better shed rain and prevent excess water from entering the uncompleted structure. In areas of wind-driven precipitation, this may be a more important consideration than preventing condensation from indoor humidity.

Early application of sheathing to a partially completed structure will help shed rainfall. If cladding is applied to vertical batten strips, it might be convenient to have both the sheathing membrane and batten strips applied to the wall panels at an early stage. This way, the walls will provide protection for the interior of the structure immediately after being erected.

Other steps that can be taken include:

- covering window and door openings with a translucent membrane, to keep rain out while admitting daylight for workers
- installing cladding at a late stage in construction, to permit drying
- pouring concrete topping early, or using treated wood in bottom plates, or both, to avoid problems with trapped moisture in the plates and to reduce the moisture load
- installing the vapour barrier late, so it does not impede drying of lumber and other components that have gotten wet during construction
- installing HRV equipment to speed up drying once the building is closed in, or heating the building at an early stage to achieve the same effect.

CONCLUSIONS

Construction Practices can help avoid increasing moisture content in wood products on site and in fact, contribute to the drying process. Closing in a structure when the wood moisture content is high can lead to degradation of the structure if wet conditions are sustained. By monitoring moisture, builders and inspectors can assess the condition of moisture-sensitive materials and take corrective action as appropriate. Given the variables that can affect moisture readings, it should be remembered that meter readings are typically accurate within 1 to 4 per cent of the true moisture content.

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Housing Research at CMHC

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