TIMBER TECHNOLOGY BULLETIN

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Measuring the moisture content of wood during processing

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Introduction

Sap, mainly water in a tree stem/trunk, is an important element to sustain the life of the tree. When a tree is felled and the trunk is converted into sawn timber and subsequently to final product, such as furniture, a large amount of this water is removed. There are many reasons for such removal—stabilizing of timber before usage, reduction of weight, enhancement of durability and strength, etc. Information on the amount of moisture present in timber at various stages of conversions or processing is crucial in maintaining the material quality and its effective utilization.

The amount of moisture in timber, or better known as moisture content (mc), is normally expressed as the percentage of water present over the oven-dry weight of timber. The process of determining the moisture content is destructive—requiring the timber sample to be dried in an oven maintained at 103 ± 2 °C until a constant weight is reached (Figure 1a & b). Other means of determining the moisture content of timber is by estimation using an electrical meter that measures either the electrical resistance or dielectric properties of timber (Figure 2a & b). These electrical meters are called resistance type or dielectric type moisture meters, respectively.

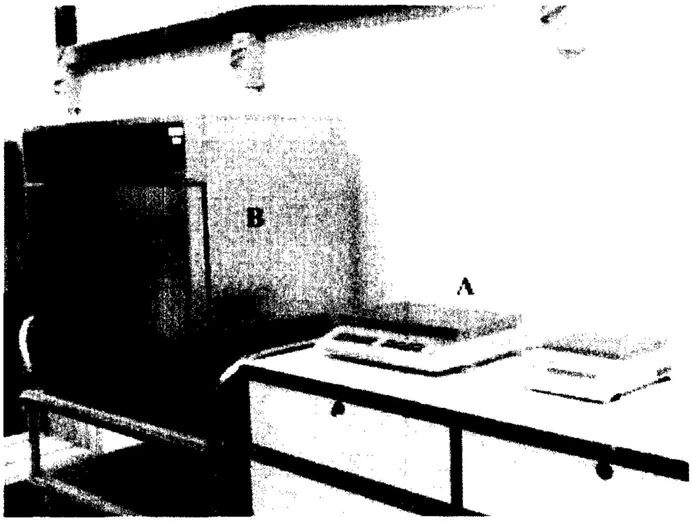

Figure 1a Oven-dry method of moisture content determination. A) Electronic balance, B) Oven—equipment required

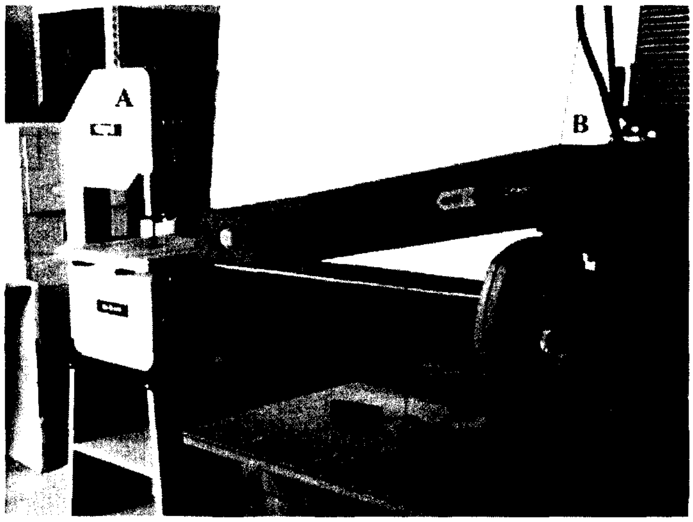

Figure 1b Oven-dry method of moisture content determination. A) Band-scroll saw, B) Radial arm-saw—for sample preparation

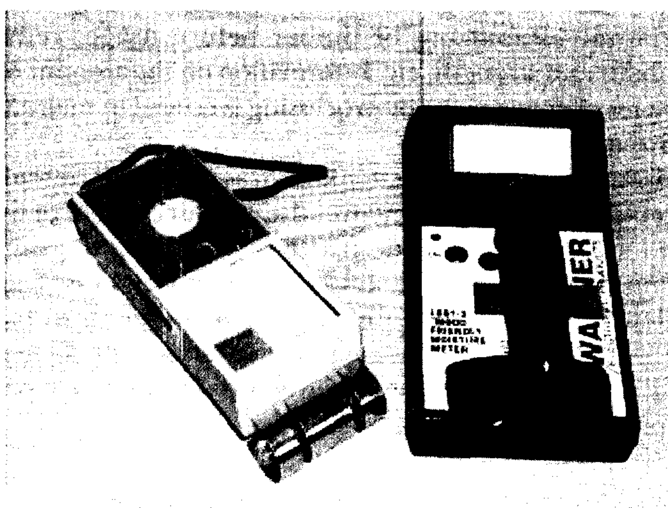

Figure 2a Dielectric type moisture meters

Figure 2b Resistance type moisture meters

Table 1 Methods of moisture content determination

	Oven-dry method	Resistance type moisture meter	Dielectric type moisture meter
Descriptions	Destructive test method Standard method for measuring wood moisture content • Based on weight loss of sample placed in an oven set at 103 ± 2 °C for 24–36 hours or until constant weight • Expressed as a percentage of oven dry weight	Non-destructive test method Measures the resistance of wood between two electrode pins that are driven into it. Leave two small holes on the timber. The meter measures the wettest wood in contacts with both pins. Reading of moisture content in percentage of oven dry weight.	Non-destructive test method Measurement based on either the power loss factor or in conjunction with the dielectric constant of the wood. Use the surface contact electrodes. A good contact between he electrode and wood surface must be established to obtain good measurement. Reading of moisture content in percentage of oven dry weight.
Species	Independent of species. However, timber species with very high volatile extractive (resin) may indicate higher moisture content than actual.	Species dependent. Each timber species has its characteristic curve and the meter readings have to be corrected, either manually based on correction table or by selecting the appropriatespecies correction setting in modern instrument.	Species dependent. Each timber species has its characteristic curve and the meter readings have to be corrected, either manually based on correction tableor by selecting the appropriate species correction setting in modern instrument.
Wood temperature	Wood temperature has no influence on moisture content determination.	Wood temperature influences meter reading. Temperature correction has to be applied either manually based on chart provided by instrument supplier or by selecting the appropriate temperature setting in modern instrument.	Wood temperature influences meter reading. Unless the temperature correction data are supplied by the equipment manufacturer, the use of this meter is restricted to ambient condition.
Moisture content (MC) distribution	MC distributions could be determined by slicing the timber accordingly.	With un-insulated pins the meter provides the value corresponding to the wettest wood. With insulated pins, the MC reading at the respective depth of pins could be measured.	The surface electrode of dielectric meter does not penetrate the wood. The electro-magnetic field penetrates up to a depth of 25 mm. However, the surface moisture has a predominant effect on the reading. As such, the meter could not be used to trace moisture distribution over the cross-section.

(continued)

Table 1 (continued)

	Oven-dry method	Resistance type moisture meter	Dielectric type moisture meter
Timber thickness	No restriction. The whole strip of cross-sectional specimen is taken into consideration for average mc.	Limited by the depth of the driven pins. To measure the average mc, the pins shall be driven to $\frac{1}{3}$ the thickness of timber.	Good for timber between 30 and 50 mm thick.
Measuring direction	Grain direction has no effect on measurement.	Slight difference on meter readings between parallel and perpendicular orientation of pins relative to grain direction. Below 15% MC the effect of grain could be neglected. Above 15% MC, the readings perpendicular to grain may be lower than that of parallel to the grain. Take note of the measuring direction indicated when using the equipment or calibration chart.	Grain direction has no influence on measurement.
Measuring range	No limitation	7 to 27%	6 to 30%
Sampling point	Specimen of 25 mm length (along the grain) shall be taken at least 300 mm from either end of a sample board. For short length timber (< 600 mm), the specimen shall be taken at the middle of the board.	Reading shall be taken at least 300 mm from either end and at the center of the wide face of a board. Measurement shall not be taken over checks, knots, resin pockets, etc.	Reading shall be taken at least 300 mm from either end and in the center of the face of a board (away and in the from the edge). Readings should be made in areas that are free of defects (checks, knots, resin pockets, etc.)
Requirements	A forced convection oven with temperature controlled at 103±2°C, a balance with accuracy 0.1 g and a suitable saw.	Meter should be easy to operate and handle. Come with instruction manual and relevant species and temperature corrections for the various timber species. A calibration standard to check the instrument accuracy.	Meter should be easy to operate and handle. Come with instruction manual and relevant species corrections for he various timber species. A calibration block to check he instrument accuracy.
Calibration	Check and/or calibrate the oven and balance.	Check for accuracy of meter by using 'check-box' supplied by equipment manufacturer regularly. Meter could be calibrated with relevant timber species should the need arise.	Check for accuracy of meter regularly by using 'standard-pad' supplied by equipment manufacturer. Meter could be calibrated with relevant timber species should the need arise.

(continued)

Table 1 (continued)

	Oven-dry method	Resistance type moisture meter	Dielectric type moisture meter
Other factors influencing the imethod/ instrument	Wood preservatives normally do not influence this method of MC determination.	Wood preservatives, adhesive and resin will influence the meter reading. Generally, chemical will increase the electrical conductance (or reduce the resistance) and resulted in higher with value. At very low 8% MC the difference may be negligible, but above 10% MC the errors grow rapidly and erratically. A reliable correction for preservative treated wood is impossible because of variable concentration and depth of chemical penetration.	Influence by wood preservatives, adhesives and other variables (such as air-space, hand, work-bench, etc. near he surface or below the timber) on reading (especially with thinner, < 25 mm thickness, material).
Skill of operator	Operators should be properly trained in each method to obtain good MC values. Selection of wood samples for MC determinations is equally important. Care shall be exercised at all time when using MC meters or balance to ensure good measurement.		

Recommendations

- Use the oven-dry method on green timber (MC > 27%) to establish a more precise moisture content for controlled drying at the early stages of kilning.
- Resistance type meters are useful when the MCs of sawn timber are in the region 7 to 27%. Both the temperature and species correction factors should be applied to obtain good measurements. May be used at later stages of kilning and sorting & checking before further processing such as planing/moulding/turning, etc.
- Dielectric type meters are useful during tertiary processing, especially for timbers after planing/moulding or under-going finishing processes, and for checking MC uniformity within and between pieces of dried timber before finger-jointing or lamination.

One can either use the oven-dry method or electrical meters, which vary in terms of accuracy and ease of measurement, to measure the moisture content of a piece of timber. Of the three, the most accurate measurement method is the oven dry method. However, such destructive method may not be applied all the times. A comparison on the characteristics of these methods is presented in Table 1.

Water in wood

To measure the moisture content confidently, it may be useful to understand how water or moisture exists in wood.

As with density variation within a tree, the amount of water in a stem/trunk varies from the cambium to the pith as well as along the stem/trunk. At the same time, there are variations between trees. As such, the moisture content in a length of freshly sawn timber may not be uniform throughout.

Water exists in timber in two forms: free water and bound water. Free water are water molecules located in the vessel while bound water are associated to the cell wall. The transfer or movements of free water are through the pits and capillary actions that do not affect the cell structures. However, the transfer/movement of bound water through the cell structure is associated with changing cell wall thicknesses, thus timber dimension.

Timber dries from the outer surfaces towards the core while the water molecules move from inside out. At any stage in the drying process, there is always a moisture gradient between the core and shell or outer surface layer of a piece of timber. In other words, the moisture content is not constant throughout its cross section (Figure 3). Towards the final stages of kiln drying, after equalizing and conditioning treatments, the moisture gradient would be reduced to a minimal level compare to early stages of drying. However, for timber that has reached equilibrium with the environment after a long period of exposure, there is practically no moisture gradient. Such an important phenomenon should be taken note of when measuring the moisture content of timber.

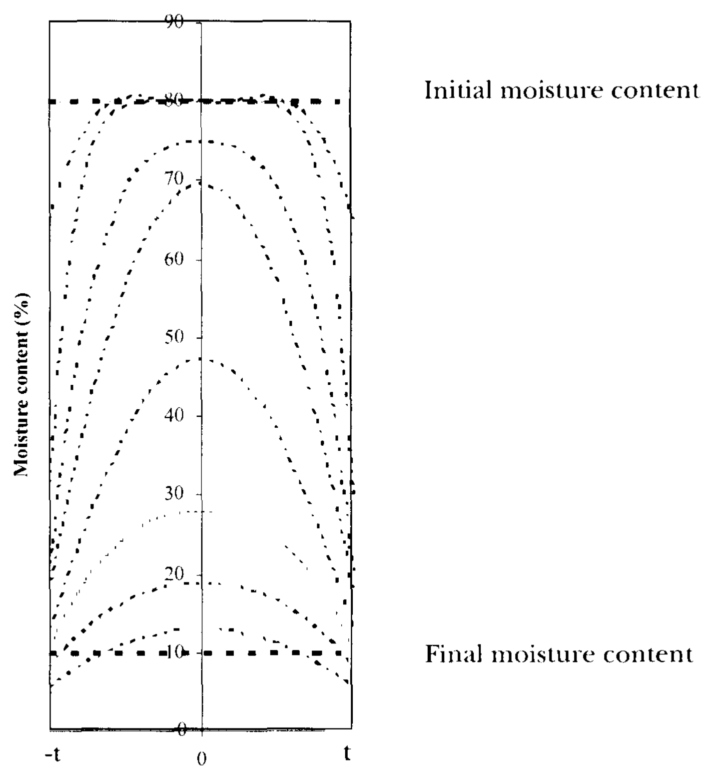

Figure 3 Moisture content distribution over the cross-section of a piece of rubberwood board (after pressure treatment to about 10% final mc) at various stages of drying

Measuring or checking of moisture content

Moisture content of timber needs to be monitored during processing, and measurements are required to be made at several stages. The frequency and accuracy required depends very much on the process requirements and the service environment the end products are subjected to.

Three typical measurement scenarios are

- Air-dried timbers
- Kiln-drying control
- Production control

Traditional timber applications require the moisture content to be in equilibrium with the outdoor/ambient environment, i.e. moisture content below 19%. Typical applications of timber in the construction of non air-conditioned installations are in roofing, staircase, flooring, walling, ceiling frames, door and window frames, and furniture (Table 1 in Anonymous 2001). This is normally achieved by air-drying. The moisture content of air-dried timbers can be checked very quickly by using the resistance type meter during the final stage of air-drying, processing and installation.

In kiln drying process, the accuracy of moisture content measurements is very crucial for process control. Without good moisture content measurement, the final drying quality of timbers may be severely affected. The only method that could be used for moisture content above the Fiber Saturation Point (FSP, ca. 28%) is the oven-dry method. Below the FSP, the resistance type moisture meter may be used. When the moisture content is above the FSP, electrical meter may produce erroneous readings that would lead to wrong decisions in process control.

Kiln dried timber is typically close-stacked, plastic-wrapped and stored under shed before final processing. However, the shed condition is often not controlled. In most cases, the moisture content of timber may rise. Therefore the moisture content would need to be checked again before the next stage of processing. Resistance type meter may be used for moisture content checking and sorting of dried timber before cross-cutting and ripping to size, finger-jointing and planing. In some instances, when dealing with planed stock, the dielectric type meters may be used to check moisture content uniformity before finger-jointing or laminating. It could also be used in the sanding and finishing sections of a production line. At these final stages of production, the oven-dry method or the resistance type meters may not be suitable; the oven-dry method is destructive while resistance type moisture meter leaves behind two unsightly holes. However, the oven-dry method may be used to verify the readings when necessary.

A typical process flow of a laminating plant and the stages where moisture content measurements are taken for process and quality control purposes is presented in Figure 4. The appropriate measurement methods are also indicated while it should be noted that the oven-dry method is used when there is suspicion on the meter measurements.

Besides accuracy of moisture content values required and ease of use, thickness of timber also determines the appropriateness of a measuring method. Figure 5 shows the influence of thickness on the moisture content measurement and the selection of the appropriate method.

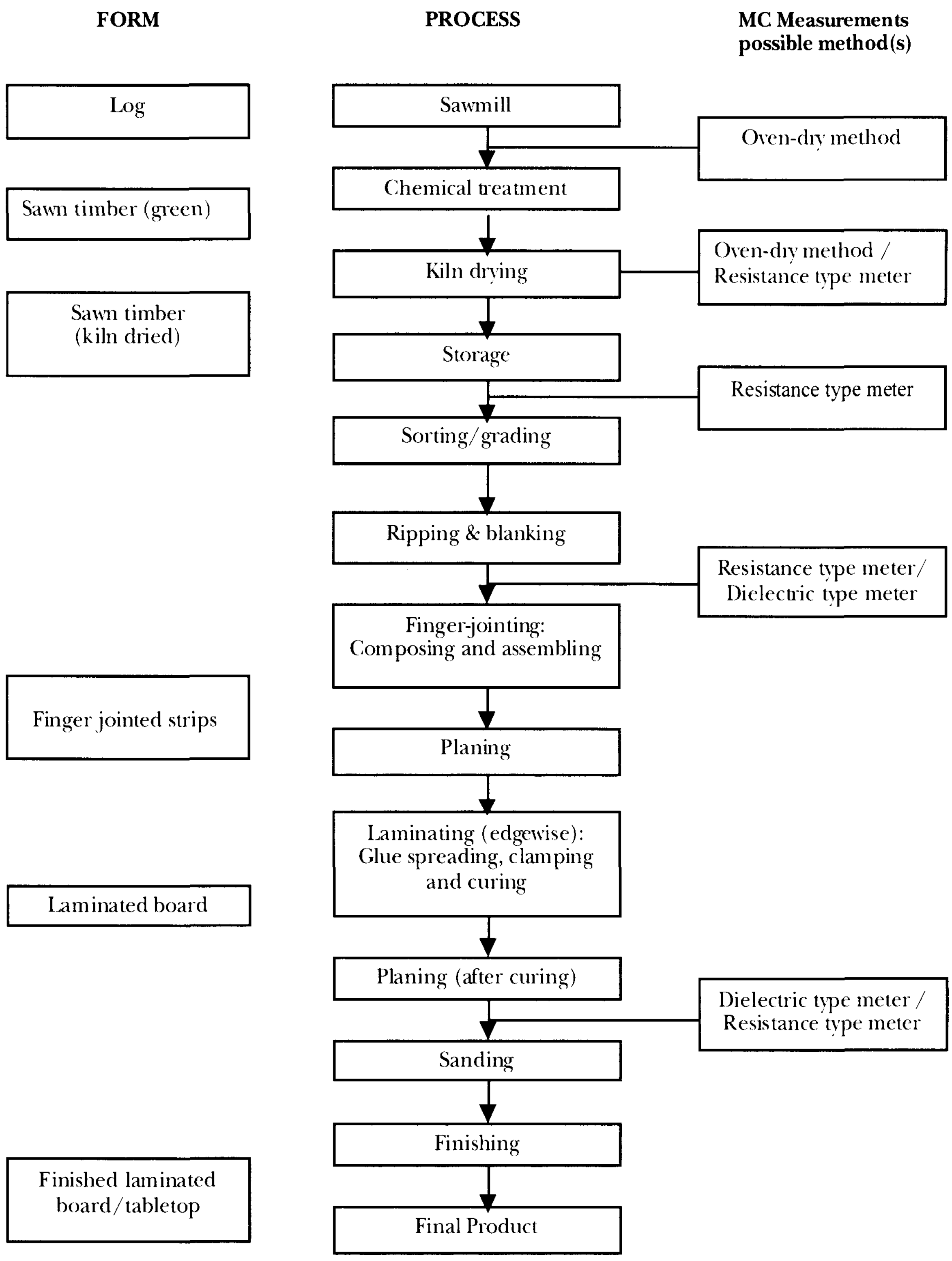

Figure 4 Moisture content checks in a typical laminating plant

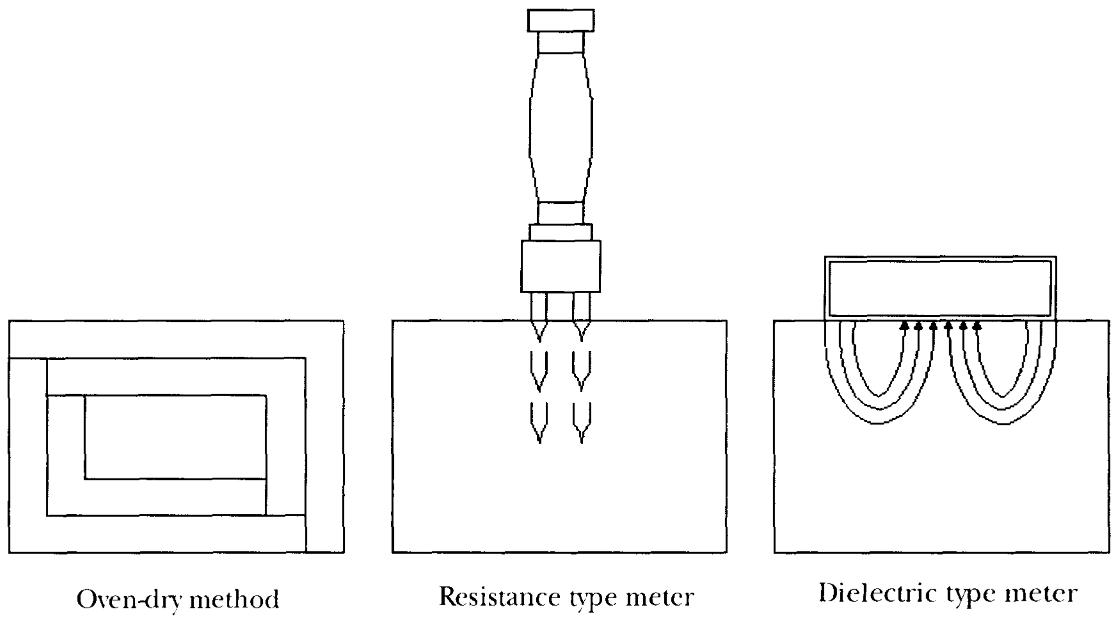

Figure 5 Effect of timber thickness on moisture content measurements: a) Shell and core samplesare cut to determine the moisture contents at different depths in the oven-dry method, b) Insulated pins of resistance type meter are driven to different depths to measure moisture contents over the thickness, and c) A ballpark measurement up to the penetration depth of electromagnetic field (ca. 25 mm) in dielectric type meter.

Accuracy of a moisture meter

The usefulness of moisture meter to a great extent depends on the accuracy of its readings. This may be looked upon at two levels: (a) accuracy of the meter and (b) accuracy of the readings for specific timber species.

Accuracy of the meter should be checked regularly against a "standard checkbox (or block)" supplied by the meter manufacturers. This will ensure that the meter is always in good working order.

Accuracy of measurements relates to the correction factors to be applied on meter reference-curve readings for specific timber species. This requires the meter readings to be calibrated against the actual moisture content of timber species concerned. Modern moisture meters may be supplied with correction factors for some Malaysian timber species. However, if correction factors for a particular timber species are not provided by meter manufacturer, the meter could be calibrated for that timber in the laboratory.

It should be noted that not all moisture meters would give the same reading for a piece of timber. When big differences occur in meter readings and dispute arises, then the oven-dry method shall be used. A neutral third party like FRIM is often referred to.

References

Anonymous. 2001. Malaysian Standard. Code Of Practice For Structural Use of Timber: Part 1: General (First Revision). MS 544: Part 1: 2001. Department of Standards Malaysia.

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