PRACTICAL MANUAL

Wood Products and Utilization

Course No. FPU 226 Credit Hrs. 3(2+1)
B.Sc. (Hons.) Forestry IV Semester

Dr. Amey S Kale
Dr. J. A. BHAT
DR. VINOD KUMAR

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College of Horticulture & Forestry
Rani Lakshmi Bai Central Agricultural University
Jhansi – 284003

Syllabus FPU 226 Credit Hrs. 3(2+1)

Estimation of specific gravity and calorific value of wood specimens. Maceration techniques and determination of sizes of fibres, vessels etc. Visits to various wood based industries like, plywood, packing case, match, tannins, furniture, saw mills etc. to study the manufacturing process. Visit to saw mill to study veneering and different kinds of sawing. Handicraft manufacturing unit. Visit to wood distillation unit. Visit to nearby industrial plantations.

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Roll No. ....

Batch ....

Session ....

Semester ....

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Date: ………………………………   Sig. of Teacher

INDEX

Practical No. 1

Objective: To determine the moisture content of wood

Material Required: ……………………………………………..…………………………………………

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Procedure: ...……………………………………………………………………………….……………

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Formula:

$$\text{Percentage of moisture content} = \frac{W_1 - W_0}{W_0} \times 100$$

Where,

W_1 = weight of sample at test in g, and

W_0 = oven dry weight of sample in g.

Calculation: …………………………………………………………………………………………..

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Practical No. 2

Objective: To familiarize with electric moisture meters

Material Required: ………………………………………………………………………………………..………

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Electric Moisture meters: ..……………………………………………………………………………………

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Electrical resistance meters: ……………………………………………………………………………………

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Capacity reactance Meters: ……………………………………………………………………………………..

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Practical No. 3

Objective: To determine the specific gravity of wood specimen

Material Required: ……………………………………………………………………………………………

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Specific Gravity (S):

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Diagram of Electric meters

Procedure: ……………………………………………………………………………………………………..
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Variations in specific gravity:
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Formula:
Specific gravity shall be calculated as given below:

Specific gravity at test = $\frac{W_1}{V_1}$

Adjusted specific gravity = $\frac{W_1}{V_1} \times \frac{100}{100+m}$

Where,

W_1 = weight in g of test specimen

V1 = volume in cm^3 of test specimen, and

m = percentage moisture content of the test specimen determined as prescribed in earlier exercise.

Note — If initial condition of the specimen is 'green' (that is well above the fibre saturation point) adjusted specific gravity, calculated by formulated by formula (b) is known as standard specific gravity; and if the specimen is dry, the specific gravity is called 'dry specific gravity'. If weight at a given moisture content is required to be calculated, the same shall be calculated as below:

Weight in kg/m^3 at a given moisture content *m* = Specific gravity at moisture content, *m* x 1000

Calculation: ……………………………………………………………………………………………...

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Practical No. 4

Objective: To determine the calorific value of wood specimen

Material Required:

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Procedure: ..……………………………………………………………………………………………..

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Formula: Calorific value of wood = heat produced / mass of wood burnt **=** $m \times s \times (T_2 - T_1) / (W_1 - W_2)$ J/g

Heat produced (Q) = mx s x t

Where, m = mass of water in grams

s = specific heat of water = 4.2.J/g/°C

t = rise in temperature of the water.

Thus, Q amount of heat is generated by g amount of fuel. The calorific value is given by the following equation.

Calorific value = Q / g joules per gram. (Value in kilo joules, divide by 1000)

The figure above shows an arrangement where a wood's calorific value is being measured. Heat the water for a while and note the rise in temperature.

Let, W_1 = initial weight of the wood

W_2 = final weight of the wood

$W_1 - W_2$ = weight of wood burnt to heat the water.

T_1 = initial temperature of water

T_2 = final temperature of the water

$T_2 - T_1$ = rise in temperature of water.

m = mass of water

s = specific heat of water in J/gm/°C

Calculation: …………………………………………………………………………………………..

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Practical No. 5

Objective: To study about maceration technique of woody material

Maceration of wood:

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Material Require:

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Apparatus required: ………………………………………………………………………………………

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Procedure:

Sample Preparation:

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Maceration:

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Practical No. 6

Objective: To study about the kinds of sawing techniques

General principles of sawing: ………………………………………………………………………………
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Types of sawing:

Plain sawing: ………………………………………………………………………………………………
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Advantages: ……………………………………………………………………………………

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Quarter sawing: ………………………………………………………………………………

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Practical No. 7

Objective: To study about adhesives used for wood composites

Adhesive: …………………………………………………………………………………………..

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Types of Adhesives

1. Natural Adhesives:

Animal Glue: ………………………………………………………………………………………

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Casein Glue: ………………………………………………………………………………………

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Vegetable protein glue: ………………………………………………………………………………

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Vegetable starch glue: ……………………………………………………………………………….

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2. Synthetic Resins

Thermosetting Resins: ………………………………………………………………………………

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Thermoplastic resins: ………………………………………………………………………………..

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Phenolic adhesives: ………………………………………………………………………………..

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Amino Adhesives: ………………………………………………………………………………..

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Practical No. 8

Objective: To study about kinds of wood composites

Composite: ……………………………………………………………………………………………

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Types of composites woods

Plywood: ………………………………………………………………………………………………

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Laminated wood:

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Coir board: ……………………………………………………………………………………………

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Sandwitch board: ……………………………………………………………………………

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Fibre board: ……………………………………………………………………………

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Particle board: ……………………………………………………………………………

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Practical No. 9

Objective: To study about types of improved woods

Improved wood: ……………………………………………………………………………………………

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Impregnated wood: ……………………………………………………………………………………...

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Heat stabilized wood: ………………………………………………………………………………...

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Compressed wood: ……………………………………………………………………………………

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Compregnated wood (COMPREG): ………………………………………………………………..

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Heat stabilized compressed wood (Staypak): ………………………………………………………

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Chemically modified wood: ……………………………………………………………………….…

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Practical No. 10

Objective: To study about the chemical wood modification of wood

Chemical modification of wood: ………………………………………………………………………

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Importance: ……………………………………………………………………………………………..

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Acetylation: ……………………………………………………………………………………………..

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Reaction with Isocyanates:

Reactions with Epoxides:

Practical No. 11

Objective: To study about the manufacturing process of plywood

Plywood: ……………………………………………………………………………………………………

Manufacturing process: ……………………………………………………………………………………

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Practical No. 12

Objective: To know about the different uses of timber in industries

No.	Name of the industry	Timber species used
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11.		
12.		
13.		
14.		

Practical No. 13

Objective: To visit wood-based industries like, plywood/ packing case/ match/ tannins

Name of the Industry:

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Company profile:

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Vision & Mission: ………………………………………………………………………………………

Infrastructure Facilities: ………………………………………………………………………………

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Product profile:

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Competitors:

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Available facilities: ………………………………………………………………………………………..

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Different stages of production/process:
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Levels of management:
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Capital structure employed- borrowed v/s owned: ………………………………………………………
Quality control, recycling of defective goods:
..…………………………………………………………………
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Working conditions for labour in observation with Labour Laws.:
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…………………………………………………………………..…………………………………………………………
Storage of raw material and finished goods:
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……………………………………………………………………..……………………………………………………
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Transport management for employees, raw material and finished goods:………………………………
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Waste Management: ……………………………………………………………………………………..
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Any other observation: ……………………………………………………………………………………..

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Practical No. 14

Objective: To visit paper manufacturing unit/cottage industry

History and importance of cottage industry in India: ……………………………………………………

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Name of the Industry/Organization: ……………………………………………………………………...

Address of the Industry/Organization: …………………………………………..…………………..

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Purpose of the visit: ……………………………………………………………………………………………

Official In-charge: ………………………………………………………………………………………………

Available facilities: ………..………………………………………………………………………………………

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The raw material and the processes used in the business: ………………………………………………

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Source of raw material: ………………………………………………………………………………………

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Different types of products: …………………………………………………………………………………

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The market, the buyers, the middlemen, and the areas covered: ………………………………………

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Cost of Production: ……………………………………………………………………………………………

Turnover per Annum: …………………………………………………………………………………………

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Working conditions: …………………………………………………………………………………………

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Modernization of the process over a period of time: ……………………………………………………

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Facilities, security and training for the staff and workers: ……………………………………………….

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Subsidies available/ availed: ………………………………………………………………………………

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Any other observation/awards and appreciations: ……………………………………………………

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Organizational flow chart

Practical No. 15

Objective: To visit furniture manufacturing unit

Name of the Institution/Organization: ……………………………………………………….............................

Introduction: ………………………………………………………………………………………………………..

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Market: ……

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Manufacturing Process: ……………………………………………………………………………………….

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Fixed Capital: ……………………………………………………………………………………………………

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Working Capital: ………………………………………………………………………………………………

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Total Working Capital Requirement: ……………………………………………………………………………

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Total Capital: ………………………………………………………………………………………………………

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Sources of Funds: ……………………………………………………………………………………………

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Cost of Production: ……………...…………………………………………………………………………..

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Turnover per Annum: …………………………………………………………………………………………

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Available lab facilities: ………..………………………………………………………………………………

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Kinds of testing done in laboratory: ……………………………………………………………………………

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List of testing machines in laboratory: ……………………………………………………………………

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Standards followed while testing: ……………………………………………………………………………….

Observations: …………...……………………………………………………………………………………

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Practical No. 16

Objective: To visit industrial plantation

Forest plantations are defined as forest stands established by planting/seeding the area for afforestation or reforestation. They are either of introduced or indigenous tree species with minimum area of 0.5 ha; tree crown cover of at least 10 percent of the land cover and total height of adult trees above 5 m.

SCALE OF PLANTATIONS: These plantations are either small scale or large scale in nature depending on various factors with large-scale plantations of fast growing tree species occupying 54 million ha in 2012 and predicted to double in extent by 2050.

Small-scale plantations are referred to as trees raised under farm forestry, social forestry, agro-forestry and integrated forestry practices on small area.

Large-scale plantations are referred to as plantations raised on large area by businesses or government agencies other than farmers for commercial purpose and to meet out large demand for wood/timber.

Field Exercise:

1. Name and location of the visiting sites: ……………………………………..

2. Date of visit: ……………………………………………………………………………

3. Details of work:

Sr. No	Species planted		Pattern of planting and spacing	Year of plantation	Duration of plantation	Area (ha)
	Scientific Name	Common Name				
1.						
2.						
3.						
4.						
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7.						
8.						
9.						
10.						

What are the objectives of plantation?………………………………………………………………..

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Write the Characteristics of industrial plantations.

Characteristics	Industrial plantation
Ownership	……………………………………………………………………………………………… ……………………………………………………………………………………………… ………………………………………………………………………………………………
Objective	……………………………………………………………………………………………… ……………………………………………………………………………………………… ………………………………………………………………………………………………
Species diversity	……………………………………………………………………………………………… ……………………………………………………………………………………………… ………………………………………………………………………………………………
Type of species	……………………………………………………………………………………………… ………………………………………………………………………………………………
Management	……………………………………………………………………………………………… ……………………………………………………………………………………………… ………………………………………………………………………………………………
Cost of establishment	……………………………………………………………………………………………… ………………………………………………………………………………………………
Profitability	……………………………………………………………………………………………… ………………………………………………………………………………………………

Importance of industrial plantations: ……………………………………………………………………..

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Management strategies used by respective authority: ……………………………………………………..

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Practical No. 17

Objective: To visit saw mill

Name of the Saw-mill: ……………………………………………………………………………………………

Address: ………………………………………………………………………………………………………

Name of the owner: …………………………………………………………………………………………….

Year of Establishment: ……………………………………………………………………………………..

Total area: …………………………………………………………………………………………………….

Total man power: …………………………………………………………………………………………….

No of skilled and unskilled labors: ……………………………………………………………………………

Timber species: ……………………………………………………………………………………………...

Storage facilities (area in sq. mts.): ……………………………………………………………………………

Source of the material: ……………………………………………………………………………………..

Method of storage: ……………………………………………………………………………………………..

Primary processing machinery: ……………………………………………………………………………..

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Secondary processing machine: ……………………………………………………………………………....

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Method of volume measurement: ……………………………………………………………………………...

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Wood volume processed daily: ………………………………………………………………………………..

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Other instruments available: ………………………………………………………………………………

Observation table:

Sr. no.	Timber species	Cost of round log	Cost of converted timber (per sq. feet)	Size of the converted timber

Safety rules followed: ………………………………………………………………………………………

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Safety equipment available: ………………………………………………………………………………

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Processing of wood waste: ………………………………………………………………………………..

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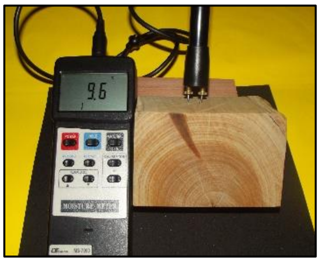
Layout of the sawmill

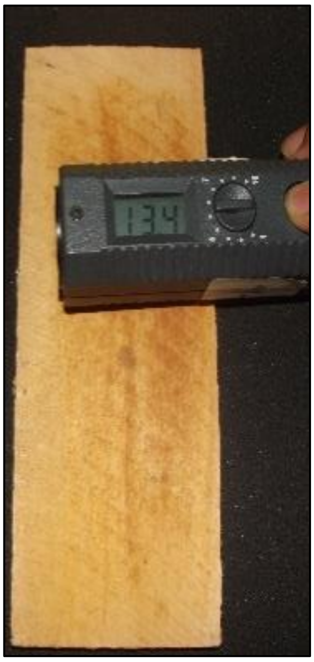
MOISTURE CONTENT OF WOOD

The specimen should have a length of approximately 2.5cm and a full section as the tested piece. In the case of a shear test, for the determination of the moisture content, the detached portion of section 5x5cm or 2x2cm shall be taken. Dimensions of 2.5cm in length and 2x2cm or 5x5 cm in cross-section should be taken when only the moisture content is to be determined.

The sample shall be weight with accuracy of 0.001g in a weighing balance and then dried in a well-ventilated oven at temperature of 103 ± 2^0C. The weight shall be recorded at regular intervals. The drying shall be considered to be complete when the variation between last two weighing, does not exceed 0.002g. The final weight shall be taken as oven dry weight.

ELECTRIC MOISTURE METERS





Resistance Dieters: The working of these meters is based upon the fact that changes in moisture content cause an appreciable change in the electrical resistance of wood. From the green state to the fibre saturation point the change in resistance is rather small, but when the moisture content falls below the fibre saturation point the resistance increases enormously. Below 8% moisture content the magnitude of the resistance of wood becomes very high, and on account of the leakage in insulation in the measuring circuit the results obtained are not reliable. Consequently, measurements with resistance meters are limited to moisture content values above 8%. The upper practical limit is slightly below the fibre saturation point, although some instruments are calibrated to give higher values also.

The resistance meters are usually provided with steel needles or knife-edge type of electrodes for passing, the current through the wood. These electrodes are mounted, a fixed distance apart; on an insulated handle and can be driven into the wood by hammering the handle. The length of the electrodes varies from 6mm to 8mm.

Capacity Reactance meters: Capacity reactance meters, which measure either the dielectric constant or the power factor, have a distinct advantage over resistance meters in that only reasonably good contact is needed and no permanent pin marks need be made on the wood. Changes in dielectric constant and power factor with moisture content are, however, relatively small compared with resistance changes. Because of this, specific gravity and ash content variations have a much greater effect upon the moisture content determinations. Frequent calibration to correct for variations in the properties of the wood handled is essential to obtain even reasonable accurate results.

SPECIFIC GRAVITY OF WOOD

The wood density or specific gravity of wood is considered to be the single most significant wood property that contributes to the quality of wood. This has a direct and significant positive correlation with pulp, paper and timber products, although wood density and specific gravity are commonly used synonymously and refer to the amount of substance present, both of which are expressed in two distinct ways. Density is the ratio of the weight of a given volume of wood to the weight of an equal volume of water, while specific gravity is the ratio of the weight of a given volume of wood to the weight of an equal volume of water.

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CALORIFIC VALUE OF WOOD

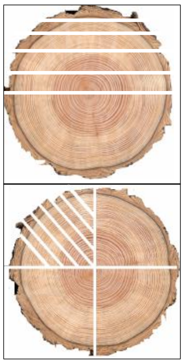
The heat produced by fuels when they are burned in joules or calories measures the fuel quality. The heat released by the fuels varies, and in terms of the number of joules or calories generated during burning, this can be distinguished. Wood has been used as fuel traditionally. Cellulose $(C_6H_{10}O_5)n$ is the principal content of wood. The presence of oxygen in a fuel encourages oxidation but does not lead to heat or its calorific value. It is actually seen that if a substance contains oxygen, when the substance bums, less heat energy per unit weight will be produced. However more heat is produced if carbon is present. The percentage of carbon in wood is quite low. This gives a far less calorific value to wood. In units of joules or calories (1calorie = 4.18 joules), heat energy is measured.

The amount of energy generated is known as the calorific value of the fuel when 1 unit mass of fuel is completely burned. Because the use of the word calorific has been in use for a very long time, the word calorific is used, not 'joulific'. It produces 33 kilos of joules when 1 gram of charcoal is burnt. Thus, 33 kJ/g is the calorific value of charcoal. Often the expression kilowatt per kilogram (KWh/kg) is used instead of a calorific value.

The instrument by which calorific value of substances is measured is called bomb calorimeter. The fuel, whose calorific value is to be measured, is first weighed (grams). This fuel is used to heat m grams of water. The temperature of the water before and after the fuel is burnt completely is measured. Let t be the rise in temperature of m grams of water when g grams of fuel are burnt completely.

There can be several errors in carrying out this experiment as (1) heat lost to the atmosphere is ignored, and by enclosing the colorimeter in the insulating box, this can be reduced. (2) By calculating the thermal potential of the beaker and using it in the equation, heat lost by the beaker is ignored and can be reduced. (3) Fuel combustion in the air that is incomplete or inadequate can be reduced since the fuel should be burned in the oxygen atmosphere and not in the air.

MACERATION TECHNIQUE OF WOODY MATERIAL



Small radial from the sample blocks were macerated to determine vessel element length, fiber length, fiber diameter and wall thickness as per Schultz's method (50% Nitric acid and a pinch of Potassium chlorate). Small chips were added into a test-tube and nitric acid was added and then a few crystals of potassium chlorate were added. Heat gently until bubbles are evolved, and let the reagent act until the material becomes white. Four or five minutes should be sufficient. The fumes are disagreeable and are very injurious to microscopes. Pour the contents of the tube into a dish of water. After the material is thoroughly washed in water, it may be teased with needles and mounted, or it may be put into a bottle of water and shaken until many of the cells become dissociated. After a thorough washing in water, the material may be stained. The large tracheids of ferns, dissociated in this way and stained in safranin or methyl green, make beautiful preparations or the macerated chips are kept in sunlight for two to four days till the chips turns to milky white. The chips are then washed with two to three times water and shake and few drops of safranin were added. The macerated wood elements are thoroughly mixed and spread on a glass slide and observations were taken under a compound microscope for vessel element length and fiber length, diameter, wall thickness.

KINDS OF SAWING TECHNIQUES

Plain sawing, successive cuts are made in the same plain, mainly in a plane tangential to growth rings. This is the simplest way of sawing with high productivity and recovery. Plain sawn boards generally have grains in multiple directions resulting in uneven drying. These boards are more prone to develop cupping, twisting and bowing and are dimensionally less stable. However drying rate of plain sawn boards is much faster than quarter sawn boards. In some species, plain sawing gives beautiful figures in "U" or "V" shapes due to growth rings. In this case knots appear as round knot on board surface.

Quarter-sawing, cuts are made more or less perpendicular to the growth rings. Quarter sawing produces quality timber with higher dimensional stability, low tendency to warp and develop surface checks, and greater resistance to abrasion. Matching grains are also much easier in quarter sawn timber. However, quarter sawing is only appropriate for large logs and is largely confined to hardwoods. The productivity in quarter sawing logs could be up to 30% poorer than in plain sawing as logs need to be turned frequently. Similarly, timber recovery is also generally lower (up to 10%) than in plain sawing. Quarter sawn wood is more prone to develop crook during drying which can be problematic. Quarter sawn boards produces specialized grain effect with ribbon like or parallel line figures due to growth ring orientation.

ADHESIVES USED FOR WOOD COMPOSITES

Thermoplastic Resins: These resins mostly harden (cures) at room temperature. Cured resin starts melting on heating and solidifies on cooling. These resins are rarely used in wood composites except joining solid wood for furniture or structural uses. Polyvinyl acetate (PVA) is an example this type of resin.

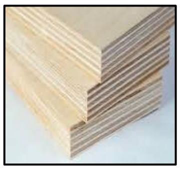
Thermosetting Resins: As the name suggests, these adhesives harden (cures) under the application of heat and once hardens it never softens upon cooling or heating. These adhesives are mostly used in wood-based composites and are of following types:

Phenolic adhesives: These adhesives are manufactured using phenolic compounds such as phenol, resorcinol with formaldehyde. Due to the higher cost of synthetic phenol, natural phenolic compounds such as cashew nut shell liquid, lignin, tannin etc. have also been used in manufacturing phenolic resin. Phenolic resins are usually darker in colour. These resins give a very durable and hot water-resistant bond. Boards made using PF resin are suitable for exterior applications including marine condition.

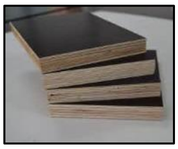
Amino Adhesives: These adhesives are manufactured by reacting amino compound such as urea and melamine with formaldehyde. The product is known as urea formaldehyde (UF) or melamine formaldehyde (MF) resin depending on the amino compound used. MF resin gives indefinite cold water but limited boiling water (100^{0}C) resistance while UF resin imparts prolonged cold-water resistance and very limited warm water (70^{0}C) resistance. Amino resins are colour less and hence preferred for decorative plywood.

Besides these phenolic and amino adhesives, other synthetic adhesives such as isocyante resins and epoxy resins are also used in manufacture wood composites. However, their commercial application is very limited due to the higher cost and used only in high niche products.

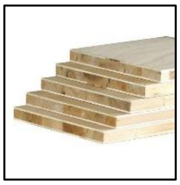
KINDS OF WOOD COMPOSITES



Plywood: Plywood is the term applied to glued wood construction built of veneers in such a manner that the grain of each veneer is at right angle to that of the adjacent veneer in the assembly. This method is called the cross-bonded construction. The most significant advantage is the modification of strength properties to a maximum advantage. The outer plies in a plywood panel are called faces, or face and back and the centre ply or plies, the core. The core may consist of veneer, timber or various combinations of veneers and timber. Plywood is used for interior walls, exterior walls, floors, doors and fitments.

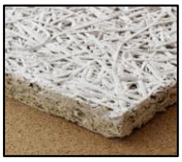


Laminated wood: Laminated wood may be defined as a built-up product made of wood layers called laminae, all laid with their grain parallel and glued or otherwise fastened together. The laminae may vary as to species, number, size, shape and thickness. Glued laminated wood construction or the structural material resulting from glued lamination, is called glulam. It is used for furniture parts, cores of veneered panels, sports goods, aeroplane hangars, auditoriums, exhibition halls, churches, green houses, gymnasia, theatres, warehouses, etc.

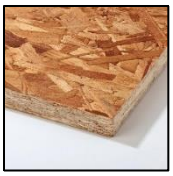


Core board: A core board is a composite board built up of a core composed of strips of wood of various dimensions glued together or otherwise jointed together to form a slab, which is in turn glued between two or more outer veneers with the direction of the grain of the core strips running at right angles to that of the adjacent veneers. It is called a batten-board when the strips of wood are not more than 7.5cm wide, a block-board when the size is not more than 2.5cm and a lamin-board when each strip of wood has a thickness not more than 7mm. It is used for doors and partitions due to its low weight, better stability, good acoustic and heat insulation properties.

Sandwich board: A sandwich board is a general term for built up boards having a core of light material, faced on both sides with a relatively thin layer of material having high strength properties. Sandwich construction are composites of different material bonded together into a unit, to achieve a combination desirable property which are not attainable with the constituent themselves individually. The construction is also economical, since the relatively expensive facing material is used only in small quantities and the core materials are inexpensive. Sandwich construction finds application in aircraft components, motor boats, table tops, flush doors and containers.



Fibre board: A fiberboard is a sheet of material made from fibers of wood. The wood is first defibrated or pulped and the fibers are then interfelted into a mat and consolidated by pressure and heat. Bonding agents and supplementary materials may be added at the felting stage to improve mechanical properties. Fiberboards are used as core material in core boards and sandwich boards. These are manufactured for the use as panels, insulating and cover material in buildings and for components of cabinets, cupboards.



Particle board: A particle board is a board or sheet constituted from fragments of wood and other ligno-cellulosic materials, bonded with organic binders with the help of one or more agents like heat, pressure, humidity, catalyst, etc. The difference between fiberboard and particleboard is that in the former the basic particle is essentially pulp made up of individual fibres or small clumps of fibres, while in the latter basic material consists of larger units in the form of chips, flakes, splinters, etc., that exhibit many of the characteristics of the original wood. They have adequate strength for interior applications in housing or furniture.

TYPES OF IMPROVED WOODS

Improved wood is a general term for wood that has been explicitly handled to decrease or postpone work (i.e., alternate swelling & shrinking) or increase its strength in different ways. Impregnation with synthetic resins (IMPREG) and other materials and/or compression (COMPREG) and/or heating (LIGNOSTONE) may be included in the procedure and may be applied to solid wood or veneers, which are then glued together. In terms of hygroscopicity, working density power, etc. the treatments have the effect of changing the properties of the wood, and for this purpose improved wood is often called MODIFIED WOOD. Improved woods have been grown from normal woods to compensate for their inadequacies and to increase their usefulness

IMPROVED WOOD TYPES AS BASED ON TREATMENT

Impregnated wood - A collective term for woods impregnated with all conceivable impregnants (wax, paraffin, resins, oils, etc.) to enhance dimensional stability and to avoid the absorption of water. Impregnated wood is a type of wood in which subdivided wood called veneers obtained by rotating cutting, slicing or sawing is treated with resin such as urea-formaldehyde, phenol formaldehyde etc. and then pressed to cure the resin bonding at sufficient pressure and temperature. The Impregnated wood have higher hygroscopicity, dimensional stability, resistance to swelling, shrinking and cracking resistance to attack of organisms

Heat stabilized wood - By a simple heat treatment that decreases hygroscopicity, it has been possible to impart a substantial degree of stability of dimension and decay resistance to wood. Heat stabilized wood is one in which a large degree of dimensional stability and decay resistance to wood is given by heat treatment. However, this involves a reduction in wood strength, particularly toughness. The process involves the treatment of wood by moving under the molten metal surface and submitting it for a few minutes to a controlled high temperature of 260-315 degree Celsius and under non-oxidizing conditions.

Compressed wood – This can be developed by modifying the compressing conditions to cause adequate flow of the lignin cementing material between the cellulose fibres to remove internal stresses. Wood is compressed without any synthetic resin impregnating it. By compression, significant changes in wood characteristics can be achieved. The compression through the fibres increases the wood's specific gravity and thus enhances the properties of strength. Theoretically, if there is no air space left in it, wood can be compressed to a specific gravity of 1.46. Pressure ranging from 90-140 kg/cm2 is applied in practice and material with a specific gravity of between 1.2-1.3 is obtained.

Compregnated wood (COMPREG) – Compregnated wood or COMPREG is wood, both impregnated and compressed with synthetic resin. After impregnating them with phenol formaldehyde resin, the timber is transformed into veneers, compressed together in a pack at the appropriate temperature and pressure. Pre-compression resin treatment increases the compressive properties and shear strength of the wood at the right angle to the compression direction of the plane. The term COMPREG is usually applicable to a specific gravity of 1.3-1.4 for the material compressed. Compreg is particularly resistant to mild acids, alcohols and a wide variety of other solvents. Compreg has 10-20 times standard wood hardness and improved wear resistance. Compreg is an outstanding aero plane propeller blade material suitable for bearings, electrical equipment, accessories for textile mills, chairs, fan blades, floor coverings, sanitary fittings, etc.

Heat stabilized compressed wood (Staypak) – By changing the compressing conditions, Staypak is created to allow the lignin cementing material between the fibres to flow sufficiently to remove the internal stresses. Staypak as compreg is not water resistant, but it is about twice as tough and has higher strength of tensile strength. Wood is compressed to a specific gravity of 1.3-1.4 and Staypak can be made of both solid and laminated wood. Staypak is around twice as tough and has higher tensile strength, MOR, and MOE. Staypak can be used in the same way as when there is no need for exceptionally high-water resistance.

Chemically modified wood – By using chemicals that substitute hydroxyl (OH^-) in cellulose with less hygroscopic groups, it has been developed to make wood less hygroscopic, simultaneously bridging structural elements to decrease their propensity to separate. Wood hygroscopicity in cellulose is due to the OH^- groups. Acetylated wood is obtained by acetylation as a result of such treatment. Acetylation in the presence of pyridine as a catalyst can be achieved by heating dry wood with acetic anhydride. This results in decreased hygroscopicity and swelling/shrinkage and the stabilization achieved in this way depends on the degree of acetylation.

CHEMICAL WOOD MODIFICATION OF WOOD

If the chemistry of the wood cell wall polymers is changed, the polymer properties change as does the performance of the modified wood. The chemical modification of wood can be defined as a chemical reaction between some reactive part of wood and a simple single chemical reagent, with or without catalyst, to form a covalent bond between the two. This excludes chemical impregnations (monomer impregnations that polymerize in situ, but do not bond with the cell wall), polymer inclusions, coatings. and heat treatments. Chemical modification of wood has been used (i) to isolate various cell wall polymers, (ii) to study differences in properties as a result of changing the chemistry. and (iii) to improve the performance properties of wood. Many chemical reaction systems have been published for the modification of wood and the systems have been reviewed in the literature. The chemicals include anhydrides (such as acetic, butyric, phthalic, succinic, maleic, propionic, and butyric anhydride), acid chlorides, ketene carboxylic acids, isocyanates, formaldehyde, acetaldehyde, difunctional aldehydes, chloral, phthalaldehydic acid, dimethyl sulfate, alkyl chlorides, 3-propiolactone, acrylonitrile, and epoxides (such as ethylene, propylene, and butylene oxides, and difunctional epoxides).

Acetylation: The reaction of acetic anhydride with wood results in esterification of the accessible hydroxyl groups in the cell wall, with the formation of by-product acetic acid. This by-product must he removed. as the human nose is quite sensitive to its odor. While this is easily done in the case of wood particles and fibers, it is somewhat difficult to do in solid wood. Acetylation is a single addition reaction, which means that one acetyl group is on one hydroxyl group with no polymerization:

$$\text{Wood–OH} + (CH_3\text{–}CO)_2O \longrightarrow \text{wood–OOC–}CH_3 + CH_3\text{–COOH}$$

Acetic anhydride Acetylated wood Acetic acid

Thus, all the weight gain in acetyl can be directly converted into units of blocked hydroxyl groups. This is not true for a reaction where polymer chains are formed (e.g., epoxides and isocyanates). In these cases, the weight gain cannot be converted into units of blocked hydroxyl groups. Acetylation has also been done using ketene gas. In this case, the wall hydroxyl groups are esterified, but no by-product acetic acid is formed. While this is an interesting chemistry and eliminates a by-product, it has been shown that the reaction rate is determined by the rate of diffusion of the vapor into the wood. Since the rate of diffusion into a porous solid varies inversely with the square of its thickness, the reaction of wood with ketene has been restricted to a maximum wood thickness of about 3 mm if it is to be carried out within a reasonable time length.

Reaction with Isocyanates: Isocyanate compounds react with OH groups of wood to form hydrolytically stable carbamate esters (urethanes) without releasing by-products. Aliphatic (mainly up to butyl) and aromatic isocyanates have been used, where the latter are more reactive than the former. Their action is mainly catalyzed by bases (preferentially by tertiary amines) but acid catalysis is principally also possible. The disadvantages of modification with isocyanates are the high toxicity and the necessity to exclude wood moisture, which make practical application not viable. Their action with isocyanates has therefore been performed in the gas phase without solvents (under high pressure) or with polar solvents such as DMF (although protic) or DMSO. One approach to avoid handling problems is to generate isocyanates with in the wood by thermal rearrangement of acyl azides. At relatively high weight gains, isocyanate- modified wood has dimensional stability similar to the acetylated wood, and is resistant to attack by both brown rot and white rot fungi.

Reactions with Epoxides: Reaction of wood with epoxides to form ethers is mainly performed under alkaline conditions, using tertiary amines (e.g., trimethylamine) as a catalyst. The main epoxides, that have been reported, are propylene oxide, butylene oxide, and epi- chlorohydrin. In addition, there action with ethylene oxide, styrene oxide, glycerol oxide, glycidyl methacrylate, and allyl-glycidyl ether has been described. There actions are mostly performed in the vapor phase at elevated pressure up to 1MPa. It is not clear, if the etherification of wood OH groups occurs predominantly, or if OH groups, formed by ring opening of an epoxide, are also added to another epoxide. If both reactions occur, it results in the formation of ether oligomers attached to wood hydroxyl groups. High dimensional stability values are obtained with propylene and butylene oxide at weight gains of 20–30%. Beyond this point, wood degrades due to disruption in the cell walls and shows higher water-uptake. Modifications with propylene and butylene oxide cause reduction in the modulus of elasticity (MOE) and modulus of rupture (MOR), fiber stress at proportional limit and crushing strength compared to unmodified samples.

$$\text{Wood–OH} + \text{R–CH(–O–)}\ CH_2 \rightarrow \text{Wood–O–}CH_2\text{–CH(OH)–R}$$

Epoxide

MANUFACTURING PROCESS OF PLYWOOD

Plywood is a term applied to glued wood construction built of veneers in such a manner that the grain of each veneer is at right angles to that of adjacent veneer in assembly. This method of assembling wood components is referred to as CROSS BANDED CONSTRUCTION, which separates plywood from pure laminated wood where the grains of successive layers are parallel. The outer plies in the plywood panel are called FACES or face and BACK, and the CENTER PLY or plies, the CORE. Plywood construction may consist of any odd number of plies. The simplest structure is of three plies. In panels having more than three plies the layers between the core and the face or back are called 'CROSS-BANDS'. Simplest plywood Construction is THREE PLY PANEL.

Steps in plywood manufacturing:

A. VENEER PREPRATION

i) Softening of logs
ii) Cutting
a) Rotary cutting (veneer produced in a long continuous ribbon of wood).
b) Stay log cutting (Modification of rotary cutting to produce Fancy face Veneers).
c) Cone cutting (produces circular sheet of Veneers by taper peeling a bolt in a manner similar to that of sharpening a wooden pencil).
d) Slicing (Slicers are used and veneers prepared as bread is sliced).
e) Sawing (Done in those woods which are highly refractory and unsuitable for slicing).

B. VENEER DRYING

i) Air drying – Drying in open.
ii) Kiln drying- (conventional progressive and Compartmental kilns are used.
iii) Loft drying- (drying in well ventilated rooms with or without humidity control).
iv) Veneer Drier: (rapid or uniform seasoning without adverse effect on sheet).

C. **PREPARATION OF VENEER STOCK FOR GLUING (**Faces, Backs, Cross bands and Cores for gluing)

i) Grading and Matching
ii) Redrying
iii) Dry clipping
iv) Jointing
v) Taping and Splicing
vi) Assembly

D. MIXING/SPREADING OF GLUE /ADHESIVES

E. PRESSING THE GLUED LAY UP INTO A PANEL (Hot and cold pressing)

F. CONDITIONING OF THE PANELS

G. FINISHING (TRIMMING, SANDING AND STORAGE)