Practical Manual

Wood Science & Technology

Course No. FPU - 326 Credit Hrs. 3(2+1)

B.Sc. (Hons.) Forestry V Semester

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2020

College of Horticulture & Forestry
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Jhansi – 284003

Syllabus FPU 326 3(2+1):
Mechanical tests on timber. Static bending, impact bending, and compression parallel and perpendicular to the grain, hardness, shear, torsion, nail and screw pulling test, brittleness test and calculation of properties. Estimation of combustibility of wood using bomb calorimeter. Estimation of directional shrinkage and swelling of wood. Familiarization of non-destructive wood testing instruments. Visit to wood testing laboratories.

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Roll No.: ....

Batch: ....

Session: ....

Semester: ....

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Date: Course Teacher

INDEX

Practical No. 1

Objective: To estimate 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 estimate specific gravity of wood

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

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Specific Gravity (S): ………………………………………………………………………………………

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

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Variations in specific gravity: ……………………………………………………………………………..

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Formula:

Specific gravity shall be calculated as given below:

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

b. 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. 3

Objective: To determine calorific value of wood

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. 4

Objective: To prepare standard specimen sizes for the evaluation of mechanical properties

List of Mechanical test conducted on the timber specimen in India

S. No.	Mechanical test	Size of specimen	Surface on which load is applied
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			

Collection of sample: While collecting the samples from the field, 10 logs of sound straight grained trees of merchantable size of average age are selected. Necessary information on the local conditions, such as soil, elevation, surroundings, usual climate, etc. should be noted. When the logs are received in the laboratory, their condition is recorded, necessary photographs are also taken for record and are marked to convert into scantlings or sticks for obtaining specimens for the various tests in green and dry conditions. All the even numbered sticks from the upper half of the log and the odd numbered sticks form the lower half of the log are sorted out for testing in green condition, the rest will be tested in the air-dry condition, all sticks

Draw diagram of different testing specimens

are to be tested under one required condition, bundled together are called as composite bolts.

Practical No. 5

Objective: To determine static bending stress

Specimen size and dimensions: ……………………………………………………………………………...

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

Measurement of load and deflection: ………………………………………………………………….

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Formula: The various characteristics shall be determined by the following formulae and from the load-deflection curve. The area shall be measured by a calibrated planimeter.

S. No.	Characteristic	Unit	Formula
1.	Fibre stress at limit of proportionality (LP)	Kg/cm^2	$\frac{3\,Pl}{2\,bh^{2}}$
2.	Equivalent fibre stress at maximum load (Modulus of Rupture MOR)	Kg/cm^2	$\frac{3Pl}{2\,bh^2}$
3.	Modulus of Elasticity (MOE)	Kg/cm^2	$\frac{pl^3}{4\Delta bh^3}$
4.	Horizontal stress (HS) on neutral plan at LP (HS at LP)	Kg/cm^2	$\frac{3P}{4bh}$
5.	Horizontal shear stress at maximum load (ML) (HS at ML)	Kg/cm^2	$\frac{3P'}{4bh}$
6.	Work (Wk) to LP (elastic resilience) (Wk to LP)	$Kg.cm/cm^3$	$\frac{CA}{lbh}$
7.	Work to maximum load (Wk to ML)	$Kg.cm/cm^3$	$\frac{CA'}{lbh}$
8.	Total work	$Kg.cm/cm^3$	$\frac{CA"}{lbh}$

where,

P = Load in kg at the limit of proportionality which shall be taken as the point in load-deflection curve above which the graph deviates from the straight line;

l - Span of the test specimen in cm;

b - Breadth of the test specimen in cm;

h - Depth of the test specimen in cm;

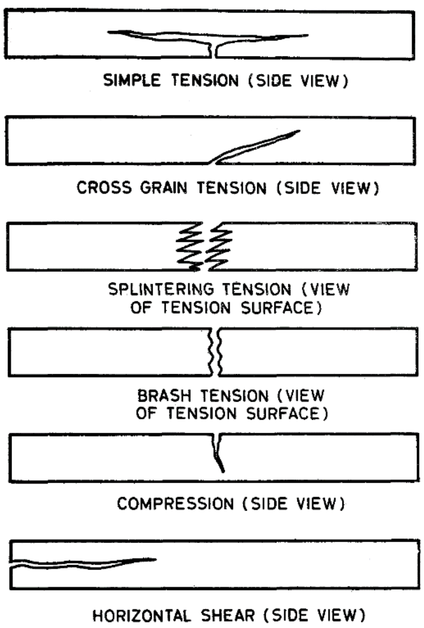
P' = Maximum load in kg;

Δ = Deflection in cm at the limit of proportionality;

C = Area constant in kg. cm (that is, the energy represented by one square centimetre which is equal to load in kg, represented by one centimetre ordinate multiplied by deflection in centimeters, represented by one centimeter abscissa);

A = Area in cm^2 of load-deflection curve up to limit of proportionality;

A' = Area in cm^2 up to maximum load; and



A″ = area in cm^2 up to the final reading when total work is required.

In the absence of suitable planimeter the work shall be calculated by the following formulae:

Work to limit of proportionality (Wk to LP) = $\frac{P}{2\,bh}$

Work to maximum load (Wk to ML) = $\frac{0.6}{lbh}\ \{P\Delta m + P'(\Delta m - \Delta) - 0.03\}$

Total Work = Wk to ML + $\frac{\mathrm{d}}{\mathrm{2lbh}}\ \{(\mathrm{P}' + \mathrm{P}")\ +\ 2(\mathrm{P1} + \mathrm{P2} + \cdots \mathrm{Pk})\}$

Where, Δm = deflection in cm at maximum load,

d = common difference of deflection between successive load reading beyond maximum load in cm,

P" = final load of 100 kg or .20 kg or load equivalent to 15 cm or 6 cm deflection as mentioned above

P_1 ...... PK = loads (ordinates) at fixed intervals of deflection between *P'* and *P"*.

For the purpose of comparison, the ratios of results of static bending tests on 5 X 5 cm to those on 2 X 2 cm cross-section shall be taken as given below:

a. Fibre stress at limit of proportionality = 0.92

b. Modulus of rupture = 0.93

c. Modulus of elasticity = 1.06

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

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Practical No. 6

Objective: To determine impact bending strength

Specimen size and dimensions:

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

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Formula:

S. No.	Characteristic	Unit	Formula
1.	Maximum height of drop	cm	H
2.	Height of drop at limit of proportionality (LP)	cm	H'
3.	Fibre stress (FS) at LP (FS at LP)	Kg/cm^2	$\frac{3H'Wl}{bh^2\Delta}$
4.	Modulus of Elasticity (MOE)	Kg/cm^2	$\frac{H'Wl^3}{2bh^3\Delta^2}$
5.	Work (Wk) to LP) (Wk to LP)	$Kg.cm/cm^3$	$\frac{H'W}{l\mathrm{bh}}$

The various characteristics shall be determined by the following formulae:
Where,

H = maximum height of drop in cm under the given weight,
H' = height of drop in cm at the limit of proportionality read from the curve (inclusive deflection x + y),
W = weight of the hammer in kg,
l = span of the test specimen in cm,
b = breadth of the test specimen in cm,
h = depth of the test specimen in cm, and
Δ = (y + x) at limit at proportionality from the curve

Calculation:

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Note: The size of the specimen shall be reported while reporting the results of this test.

Practical No. 7

Objective: To determine compressive strength parallel to grain

Specimen size and dimensions: ………………………………………………………………………………...

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Procedure: ……………………………………………………………………………………………………

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Rate of loading: ….…………………………………………………………………………………………..

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Measurement of Load and Deflection: ………………………………………………………………

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Formula: The various characteristics shall be determined by the following formulae:

S. No.	Characteristic	Unit	Formula
1.	Compressive stress (CS) at LP (CS at LP)	Kg/cm^2	$\frac{P}{A}$
2.	CS at maximum load(ML) (SC at ML)	Kg/cm^2	$\frac{P'}{A}$
3.	Modulus of Elasticity (MOE) in Compression to parallel to grain (MOE in Compression II)	Kg/cm^2	$\frac{LP}{\Delta A}$

Where,

P = Load at the limit of proportionality in kg,
A = Cross-sectional area in cm^2,
P' = Maximum crushing load in kg,
L= Gauge length between compressometer in cm (for 2 X 2 X 8 cm L shall be the length of specimen in cm), and
A = Deformation at the limit of proportionality in cm.

For the purpose of comparison the ratio of results of 5X 5 cm and 2 X 2 cm cross-section shall be taken as 0.98.

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

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Draw diagram of specimen depicting the kinds of failure observed while testing

Practical No. 8

Objective: To determine compressive strength perpendicular to grain

Specimen size and dimensions: ………………………………………………………………………………...

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

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Formula: The various characteristics shall be determined by the following formulae:

S. No.	Characteristic	Unit	Formula
1.	Compressive stress (CS) at limit of proportionality (LP) (CS at LP)	kg / cm2	$\frac{P}{A}$
2.	Compressive stress at compression of 2.5 mm	kg / cm2	$\frac{P'}{A}$
3.	Compressive strength at maximum load (ML) (CS at ML)	kg / cm2	$\frac{P_0}{A}$
4.	Modulus of elasticity (M of E) in compression perpendicular to grain (MOE in Compression)	kg / cm2	$\frac{P}{A} \times \frac{h}{\Delta}$

Where,

P = Load at the limit of proportionality in kg,

A = Area of the cross-section normal to the direction of load in cm^2, (5 X 5 cm or 5 X 2 cm),
P ' = Load at 2.5 mm compression in kg,
P_0 = Maximum load if reached at a compression less than 2.5 mm in kg, *h* = Height of the specimen in cm, and
Δ = Deformation at the limit of proportionality in cm.

For the purpose of comparison of compressive stress perpendicular to grain at elastic limit the ratio of results of 5 X 5 cm and 2 X 2 cm cross-section shall be taken as. 1.07.

Calculation: ……………………………………………………………………………………

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Practical No. 9

Objective: To determine shear strength parallel to grain

Specimen size and dimensions: ……………………………………………………………………………...

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

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Formula: Maximum shear stress (MSS) = load / area

Calculation: ……………………………………………………………………………………………

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Draw diagram of specimen for shear strength parallel to grain

Practical No. 10

Objective: To determine tensile strength parallel to grain

Specimen size and dimensions:

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

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Formula: The various characteristics shall be determined by the following formulae:

S. No.	Characteristic	Unit	Formula
1.	Tensile stress at proportional limit (TS at PL)	kg / cm2	$\frac{P}{A}$
2.	Tensile stress at maximum load (TS at ML)	kg / cm2	$\frac{P'}{A}$
3.	Modulus of elasticity in tension parallel to grain (MOE in tension)	kg / cm2	$\frac{LP}{\Delta A}$

Where, P = Load at the limit of proportionality in kg,
A = Cross-sectional area in cm^2,
P = Maximum load to cause the failure of the specimen in kg, *L* = Gauge length between extensometer points in cm, and
A = Deformation at the limit of proportionality in cm.

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Draw diagram of specimen for tensile strength parallel to grain

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Practical No. 11

Objective: To determine tensile strength perpendicular to grain

Specimen size and dimensions:

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Procedure:

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Formula: Maximum tensile stress = load / area

Calculation: ……………………………………………………………………………………………

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Draw diagram of specimen for tensile strength perpendicular to grain

Practical No. 12

Objective: To determine nail and screw holding power

Specimen size and dimensions:

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Preparation of test specimen & Procedure: …..……………………………………………………………..

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Note: The maximum load required to pull out the nails or screws shall be recorded for radial, tangential and end surfaces

Draw diagram of specimen for nail screw holding test

Practical No. 13

Objective: To study volumetric shrinkage of wood

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

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

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Formula:

Volumetric shrinkage from initial condition to required dry condition = $\frac{V_1 - V_2}{V_1} \times 100$ percent of volume in original condition

Percentage of moisture content = $\frac{W_1 - W_2}{W_1} \times 100$

Where,

W_1 and V_1 = weight in g and volume in cc at initial condition (usually green)

W_2 and V_2 = weight in g and volume in cc at the initial required dry condition at percent moisture content (usually 12 percent moisture content or oven dry condition)

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

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Practical No. 14

Objective: To familiarize with non-destructive testing of timber

Importance: ……

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Resonance frequency method:

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Formula: The following formula is used for calculating modulus of elasticity

$$E = (0.952) \times \frac{L^4 f^2 D}{H^2}$$

Where,

E= Module of elasticity in transverse vibration
L= Length of specimen
D= Density at test
h = height of specimen
f = fundamental resonance frequency in transverse vibration.

Ultrasonic transmission method (UTM): ……………………………………………………………

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Formula: By using below formula find dynamic modulus of elasticity

$$Ed = DV^2$$

Where Ed = Dynamic modulus of elasticity

D = Density of sample at test.

V = Velocity of pulse through specimen along the grain direction Velocity V = $\frac{\text{Distance}}{\text{Time}}$

Calculation: ……………………………………………………………………………………………………

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Practical No. 15

Objective: To identify various wood cutting instruments and its uses

Horizontal Band Saw	
Vertical band Saw	
Combiner	
Cross Cutting Saw	
Hand Jig Saw	
Belt Sander	
Power Chain Saw	
Hand Saw	
Frame Saw	
Bow Saw	
Axe	
Chisel	
Wedge	
Hand drill	
Stand drill	

Practical No. 16

Objective: To study different end uses of timber in industries

S. No.	Name of the industry	Timber species used
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2.		
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Practical No. 17

Objective: To study timber joinery

List of Common types of Joints

Butt joint: ……………………………………………………………………………………………………..

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Cross Lapped joint:

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Dado joint:…………………………………………………………………………………………………

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Dovetail joint: ……………………………………………………………………………………………

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Doweled joint: ……………………………………………………………………………………………

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Miter joint: ……………………………………………………………………………………………..

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Mortise and Tenon joint: ……………………………………………………………………………......

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Scarf joint: ……………………………………………………………………………………………..

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Tongue and groove: ……………………………………………………………………………..................

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Joints using mechanical fasteners: ………………………………………………………………………

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Draw diagram of various joints

Practical No. 18

Objective: To visit Timber testing laboratory

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

Name of the Department: ……………………………………………………………………………………..

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

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

Scientist In-charge/HoD of the Department: …………………………………………………………………

Laboratory accreditation: ……………………………………………………………………………………...

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

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Kinds of testing being 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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GLOSSARY OF TERMS

Additive — Any material introduced prior to the final consolidation of a board to improve some property of the final board. Fillers and preservatives are included under this term.

Adhesive — A substance capable of holding materials together by surface attachment.

Air-Dried Timber — The condition of timber which has been subjected to air seasoning.

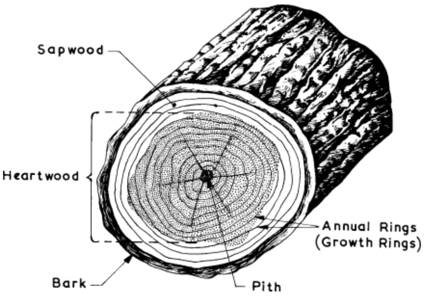
Air-Seasoned Timber — Timber seasoned in open air, usually protected from sun and rain.

Air-Seasoning — Seasoning done in open air, usually protected from sun and rain.

All-Heart — Timber containing heartwood only and completely free from sapwood.

Anisotropic — Exhibiting different properties when tested along axes in different directions.

Annual Ring — A co-axial layer of wood formed during one year of growth.



CROSS-SECTION OF LOG

Bamboo — Tall perennial grasses found in tropical and sub-tropical regions. They belong to the family Poaceae and sub-family Bambusoidae.

Bamboo Clump — A cluster of bamboo culms emanated from a single mother rhizome over a time period at the same place.

Bamboo Culm — A single shoot of bamboo in a bamboo clump.

Bamboo Mat Board — A board made of two or more bamboo mats bonded with an adhesive.

Bamboo Mat Corrugated Sheet — A sheet made up of adhesive soaked and coated mats assembled and pressed under specified temperature and pressure to obtain sinusoidal or other suitable corrugations.

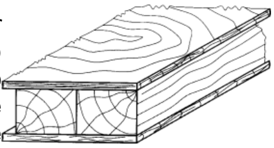
Bamboo Mat-Veneer Composite — Panel manufactured with a combination of bamboo mat and veneer. Bamboo mat can be either used as outer skins or as core/cross-bands. However, the composite panel shall be a balanced construction on either side of central ply.

Bark — The covering or rind of a tree outside the wood.

Bark Pockets — Bark enclosed or occluded in the wood.

Batten — A piece of sawn timber whose cross-sectional dimensions do not exceed 5 cm in either direction.

Batten Board — A board having a core made up of strips of wood usually 8 cm wide, each laid separately or glued or otherwise joined to form a slab which is glued between two or more outer veneers with the direction of the grain of the core battens running at right angles to that of the adjacent outer veneers.



Baulk — A piece of sawn timber whose cross- sectional dimensions exceed 5 cm in one direction and 20 cm in other direction.

Beam — A structural timber generally long in proportion to its width and thickness and used for supporting load primarily by its internal resistance to bending. In commercial practices it is sometimes used to mean 'flitches'.

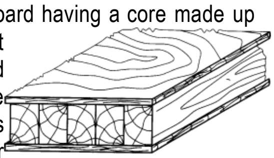
Bearer — A beam supported at two or more points and provided for the purpose of distributing the loads to the different columns.

Bent Wood — Solid wood artificially bent to shape.

Billet — A short length of a thin stem or branch wood.

Binder — Organic binding material used for adhesion of timber members.

Blockboard — Blockboard is a board having a core made up of strips of wood, each not exceeding 30 mm in width, laid separately or glued or otherwise joined to form a slab which is glued between two or more outer veneers, with the direction of the grain of the core blocks running at right angles to that of the adjacent veneers.



Blocks — A series of compartments within a reasonable geographical area convenient for location and mapping.

Board — A term used to denote thin planks.

Bole — The main stem of a tree without main branching.

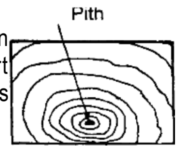
Bolt — A short log 1.5 m or less in length.

Bond — Adhesion between two surfaces of two components of the wood.

Bonding — The process of uniting two or more pieces of wood or veneers by means of an adhesive. This process is characterized by continuity of the union over the whole of the areas of contact.

Bow — A curvature in a piece of timber along its face in the direction of its length.

Boxed Heart — A piece of timber, so sawn or hewn that the pith or the centre heart falls entirely within the four surfaces throughout its length.



Break-Down — Initial operation involved in sawing a log longitudinally from the round into cants and also converting cants into large sizes of timber preparatory to manufacture.

Breaking Strength — A term loosely applied to a given structural member with respect to the ultimate load it can sustain under a given set of conditions.

Break-Off — The uncut wood fibres left between the felling cut and felling sink.

Brown Rot — A type of wood-destroying fungus that decomposes cellulose and associated pentosans, leaving the lignin in unaltered state; the resultant mass of decayed wood of varying shades of brown.

Bucking — Cross-cutting of the felled tree perpendicular to the axis of the log.

Burr — A large bulge or excrescence that is formed on the trunk or branches of a tree.

Butt — The end of bole or log nearer the stump.

Butt-End — The bottom end of the felled tree where the felling cut is given.

Buttress — An extraneous growth of the lower portion of the trunk.

Cable Puller — Device consisting of a system of lever pulley blocks and wire ropes employed to fell a tree in a given direction.

Callipering Height — Height above ground level at which the girth of a tree is generally measured. It is taken as 1.37 m.

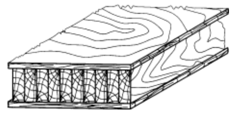
Case Hardening — A condition of timber during seasoning in which the different layers of wood are under stress by being under compression across the grain (usually due to rapid surface drying in the kiln).
Cellulose — A carbohydrate, forming the fundamental material of all plants and a main source of the mechanical properties of biological materials.
Cell Wall — The limiting membrane of a cell usually comprising several layers particularly in wood.
Cement Bounded Particle Board — Cement bonded panels made of wood particles of fairly uniform size and quality.
Characteristic Load — The value of loads which has a 95 percent probability of not exceeding during the life of the structure.
Characteristic Strength — The strength of the material below which not more than 5 percent of the test results are expected to fall.
Circular Saw — A steel disc havinga number of shaped teeth around its periphery.
Clearance Angle — The angle between the tangent to the cutting circle and the grinding back of the saw teeth.
Clear Timber — Timber which is free from defects and blemishes.
Cleavability — The ease with which bamboo can be split along the longitudinal axis. The action of splitting is known as cleavage.
Closed Assembly Time — The time elapsing between assembly of the joint components and the application of pressure.
Closed Contact Adhesive — A non-gap-filling adhesive suitable for use only in those joints where the surfaces to be joined may be brought into close contact by means of adequate pressure and where glue line exceeding 0.12 mm may be avoided with certainty.
Coir Veneer Board — A panel material manufactured with a combination of coconut fibre needled felt, veneer and jute fibres with kraft paper. Coconut fibre needled felt can be used as core/ crossbands or as outer skins formed with jute fibres and kraft paper. However, the composite ply should be a balanced construction on either side of central ply. The blended mass of glued fibres is laid toform a mat which is pre needled.
Collapse — The corrugated appearance of timber caused due to excessive but uneven shrinkage during drying.
Column — A structural member which supports load primarily
Commercial Grading — Also sometimes known as 'yard grading' or 'utility grading' refers to the principle by which the material is graded by consideration of usefulness of the material, and price factors.
Compartment — A fixed territorial unit of a forest block for the purpose of administration and management of forest.
Composite — A product obtained by bonding galvanized iron sheet or aluminium sheet to plywood on one side or both sides.
Compreg — A wood-based laminated material made from thin wood veneers either impregnated under vacuum and/or pressure with synthetic resins or coated with synthetic resin or interlaid with synthetic impregnated paper and further bonded and densified under heat and pressure. The synthetic resins are usually of phenol and cresol formaldehyde type.
Compression Failure — Deformation caused by the wood being overstressed in compression due to normal forces during the growth of the tree or felling trees on irregular ground or rough handling of logs. The deformations range from well-defined buckling of the fibres, visible to the eye as wrinkles across the face of the piece, to slight crinkling of fibres.
Compression Wood — Abnormal wood, which is formed on the lower sides of branches andinclined stems of coniferous trees. It is darker and harder than normal wood but relatively low in strength for its mass. It may be usually identified by wide eccentric growth rings with abnormally high proportion of latewood.
Conditioning — The process designed to suit the moisture content of timbers to the conditions and purposes for which it is to be used.
Core — The inner layer or layers of a composite wood product.
Core Board — A general term for block board, laminated board and batten board.
Crack — An actual rupture of the wood tissues, that is a separation of the fibres in the longitudinal direction.
Crook — A short length of naturally curved timber.
Crookedness — A localized deviation from the straightness in a piece of bamboo.
Cross-Cutting — Cutting timber across the grain.
Cup — A curvature in a piece of timber across the grain or width of the piece.

Curvature or Sweep — The deviation from the straightness of log, culm or a pole.
Cutting Angle — The angle between the face of the cutter and the line joining the cutting edge to the centre of the block.

Cutter Head Speed — The rate, in revolutions per minute, at which the cutter head is revolving.
Cutting Speed — The speed at which timber is cut.
Decay — Disintegration of wood tissues caused by fungi (wood destroying) or other micro- organisms.
Decorative Veneers — Veneers having attractive appearance due to figure, colour, grain, lustre, etc.
Defect — An abnormality or irregularity in wood which lowers its technical quality or commercial value by decreasing it in strength and affecting adversely its use or its appearance or in further conversion.
Defibration — The process of fibre separation under the influence of steam and heat, where lignin gets softened and the fibres can be separated from each other by a low energy output.
Delamination — Separation of plies, laminae or bamboo mats through failure of glue
Density - Mass per unit volume (kg/m3 or g/cm3)
Delimbing — Cutting off the side branches of a felled tree flush to the stem.
Dielectric Constant — The ratio of capacitance of wood and capacitance of air is defined as dielectric constant or the electrical permittivity of the wood.
Discolouration — A change from the normal colour of the wood or bamboo which does not impair the strength of the wood, bamboo or bamboo composite products.
Drilling — Making round holes on the surface of timber by means of drilling machine or hand drill.
Dubbling — A thickness deficiency along the edge of a particle board caused by faulty sanding.
Durability — Resistance offered by wood to agents of natural destruction like insects and fungi.
Equilibrium Moisture Content — The moisture content which is attained by wood when placed in a constant condition of temperature and humidity

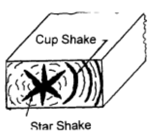
Face — The outer sides/surfaces of panels (plywood, block board, flush door, medium density fibre board and particle board).
Feed Rate — The rate in millimetres per second at which material is passing through the machine.
Fibre — A comparatively long, narrow cell of wood or bast with closed ends.
Fibre Board — Panel product manufactured under pressure and heat from fibres of any wood or lignocellulosics with primary bond deriving from interfelting of the fibres.
Fibre Saturation Point — The condition of timber with respect to moisture content when all free water has dried out and the cell walls are saturated with moisture. Above this moisture content there is no significant variation in strength, shrinkage or other physical properties.
Fibril — A thread-like component of cell walls, visible under an optical or light microscope.
Fibril Angle — The angle between the longitudinal axis of the cells and the direction of the fibrils in the cell wall.
Filler — An inert substance, such as wood flour, added to the adhesive to prevent excessive penetration of resin to the surface.
Flame Retardant — A substance when suitably added to the plywood reduces the rate at which the flame will spread across the surface of plywood or penetrate it.
Flush Door — Flush door is a timber framed blockboard. It can be either solid or hollow core.
Fundamental or Ultimate Stress — The stress which is determined on a specified type/size of culms of bamboo, in accordance with standard practice and does not take into account the effects of naturally occurring characteristics and other factors.
Gang Saw — A saw in which several blades are mounted on a frame such that a whole log can be converted in a single pass.
Gauge (of the Saw Blade) — Thickness of a saw blade.
Green Timber — Freshly felled timber which has not lost much of its moisture or timber which still contains free water in its cell cavities. Moisture content of such timber is above fibre saturation point.
Growth Ring — A layer of wood apparently produced in one growing season. The duration of a growing season may not always be one year.
Gullet — Space in a saw blade between successive teeth to carry the saw dust.
Gypsum Board — Panels manufactured from chips, particles, flakes etc. of wood or other lingo- cellulosic materials, bonded together with mineral binders other than cement and chemical additives.
Half Wrought — Semi-finished timber on which further operations have to be done either by hand or by machine in order to complete the process.
Hardboard — Panel material generally exceeding 1.5 mm in thickness manufactured from lignocellulosic fibre with the primary bond deriving from the felting of the fibres and their inherent adhesive properties.
Hardener — A material used to promote the setting of the resin. It may be either in liquid or powder form. It is an essential part of the adhesive, the properties of which depend upon using the resin and hardener as directed.
Hardwood — A conventional term used to denote the wood of broad-leaved trees. It has no relationship with the physical properties of hardness or strength. On account of the confusion this word has caused, its use is discouraged.
Heartwood — The inner portion of wood in a tree or a log, which is generally of a darker colour. It is usually devoid of living cells and reserve materials like starch and, therefore, is less liable to insect and fungal attack than sapwood.
Hemi Cellulose — The polysaccharides consisting of only 150 to 200 sugar molecules, also much less than the 10 000 of cellulose.
Honeycombing — Internal cracks (separation of fibres) in timber due to drying stresses.
Horizontal — The main horizontal members interconnecting columns
Impregnated Overlay — An overlay paper impregnated in any suitable synthetic resin and dried to a volatile content of 4 to 8 percent.
Insulating Board — Fibreboard with a density usually not more than 0.35 g/cm3, sometimes known as softboard.
Internode — The portion of bamboo between two nodes.
Irregular Grain — A comprehensive term, covering all cases where the grain, noticeably, is not parallel to the appropriate edges and to the face of the veneer. The main forms of irregular grain are short grain, wavy grain and wild grain.
Joint — A prepared connection for joining adjacent pieces of wood, veneer, etc.
Joist — A beam directly supporting floor, ceiling or roof of a structure.
Jungle Wood — A loose term used for miscellaneous unclassified timbers.
Kerf — Width of the cut made by any type of saw.
Kerf Loss — Loss of timber during sawing in the form of saw dust due to saw cut.
Kiln — A chamber in which temperature, humidity and circulation of air may be controlled for seasoning timber.
Kiln Seasoning — The process of seasoning timber in a kiln. Syn. 'Kiln- Drying'.
Knob — A hard rounded protuberance on the surface of the log.
Knot — A branch base or limb embedded in the tree or timber by natural growth.

Laminate — A product made by bonding two or more layers (Laminae) of material or materials.
Laminated Wood — An assembled product made up of layers of wood and adhesive in which the grains of adjacent layers are parallel.
Laminated Veneer Lumber (LVL) — A structural composite made by laminating veneers 1.5 to 4.2 mm thick, with suitable adhesive and with the grain of veneers in successive layers aligned along the longitudinal (length) dimension of the composite.
Lamin Board — A board having a core of strips, each not exceeding 7 mm in thickness, glued together face to face to form a slab which in turn is 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 outer veneers.



Latewood — The portion of the wood that is formed in the later part of growth season and consists of thicker walled cells.
Lignin — A polymer of phenyl propane units, in its simple form ($C_6H_5CH_3CH_2CH_3$).
Limit if Proportionality - When continuously increasing load is applied on a member, it starts deforming. Initially, the deformation is very slow and as the time elapses, the deformation increases leading to failure. Up to a certain limit, the deflection increases linearly with applied load and that point is referred as limit of proportionality
Log — A log is the trunk of a tree that is felled and prepared for conversion.

Lumber — Converted timber.
Machine Burn — It is evidenced by the dark charred patches on machined wood and is due to heating of the cutting tools.
Marine Plywood — A plywood used in the construction, repair and maintenance of marine and river craft and capable of withstanding rigorous conditions involving changes in temperature, humidity and alternate wetting and drying.
Mat — A woven sheet made using thin slivers
Mature Wood — Wood characterized by relatively constant cell size, well developed structural patterns, and stable physical behaviour. Syn. 'Adult Wood'.
Maximum load bearing capacity - The maximum load where the member fails.
Medium Density Fibreboard — A panel product manufactured from lignocellulosic fibres combined with synthetic resin or other suitable binder. The panels are manufactured to a specific gravity of 0.6 to 0.9 by the application of heat and pressure by a process in which the inter fibre bond is substantially created by the added binder.
Microfibril — A thread like component of the fibrils of the cell wall, from 10 to 40 nm in diameter, visible under an electron microscope; believed to be composed of chain molecules and cellulose extending through regions of parallelism and order (crystallites) and regions of non-parallelism and/or disorder (amorphous regions).
Modulus of Elasticity in Bending — Stiffness of the timber calculated from bending tests.
Modulus of Rupture — The maximum bending stress to failure determined from static bending tests.
Moisture Content — The mass of water present in wood or other material expressed as a percentage of its oven-dry mass.
Moisture Gradient — A gradation in the moisture content in successive layers of wood.
Mortise — A hole or slot to receive a tenon or dowel of corresponding size.
Moulding — Shaping timber to a required outline or contour.
Non-decorative Veneers — Veneers, usually peeled, without specific decorative characteristics. They are often used for the cores of plywood.
Open Assembly Time — The time elapsing between the application of the adhesive and assembly of the joint components.
Oriented Strand Board — Special type of platen pressed board, wherein the strands are all oriented in the same direction, thereby improving the strength characteristics of the board, in the direction in which the strands are oriented.
Oven-Dry/Oven Dried Timber — The condition of timber or panel dried in an oven at 103 ±2oC until its mass becomes constant.
Particle — Distinct particle or fraction of wood or other lignocellulose material produced mechanically for use as the aggregate for a particle board. This may be in the form of flake, granule, shaving, splinter and sliver.
Particle Board — A board manufactured from particles of wood or other lignocellulose material, for example, flakes, granules, shavings and slivers or splinters, agglomerated, formed and pressed together by use of an organic binder together with one or more of the agents, such as heat, pressure, moisture and a catalyst.
Particle Board of Ligno-cellulosic Material other than Wood — Particle board of bagasse, flex, hemp, straw or other non-wood ligno-cellulosic materials.
Patch — A piece of sound veneer placed in and glued to a veneer from which the defective portion has been removed.
Permissible Stress — Stress obtained after applying factor of safety to the ultimate or basic stress.
Permeability - Ease of fluid-flow under hydro-dynamic conditions. Permeability of any liquid in wood mainly depends on its anatomical structure particularly the interconnectivity of cells, sapwood/heartwood, grain orientation, moisture content, pressure and the liquid characteristics
Pitch Pocket — Accumulation of resin between growth rings of coniferous wood as seen on the cross-section.
Plain Sawn Timber — Wood so sawn that the tangential face is exposed on the surface of the plank.
Plank — A piece of sawn timber whose thickness does not exceed 5 cm but the width exceeds 5 cm.
Ply — The individual layer of veneer forming the plywood.
Plywood — A panel formed of three or more layers of veneer glued together, usually with the grain of adjacent veneers running at right angles to each other.
Pocket Rot — A decay limited to pockets or small areas surrounded by apparently sound wood.
Pole — Round log used as support for communication lines, power lines and for hop growing.
Prelaminated Medium Density Fibreboard — A medium density fibreboard laminated on both surfaces by synthetic resin impregnated base papers with or without impregnated overlay under the influence of heat and pressure.
Prelaminated Particle Board — A particle board laminated on both surfaces by synthetic resin impregnated base papers under the influence of heat and pressure or with finished foils under the influence of pressure or pressure and heat depending upon the type of binder used.
Preservation — Treatment of timber with chemicals so as to enhance its durability.
Preservative — A substance when suitably applied to the timber or plywood makes it resistant to attack by fungi, termite and other insects or marine borers.
Primer — An undercoat given on the surface for subsequent painting where required.
Pulp (Wood, Other Fibrous Lignocellulosic Materials or of Waste Paper) — Wood, other fibrous lignocellulosic materials or waste paper broken down into fibres by mechanical or chemical means, so as to be suitable as raw material for the manufacture of paper, paperboard or the products of dissolving pulp. It includes knot pulp, reject pulp and fluff pulp.
Purlins — A roof member directly supporting roof covering or common rafter and roof battens.
Putty — Pasty material used to repair the cracks, splits or holes in the plywood or wood based panels which sets on application on the panels.
Quarter-Sawn Timber — Wood so sawn that the radial face is exposed on the surface of plank.
Rails — Horizontal members of shutters of doors, windows, panels or fencing.
Rebate — A recess along the edge of a piece of timber to receive another piece or a door, sash or frame.
Reeper — Batten used in roof construction.
Ripping — Sawing timber lengthwise along the grain.
Round Timber — Timber in the original round form.
Sawdust — Wood dust produced in the process of sawing.
Scantling — A piece of timber whose cross- sectional dimensions exceed 5 cm but do not exceed 20 cm in both directions.
Seasoned Timber — Timber whose moisture content has been reduced to the specified minimum under more or less controlled processes of drying.
Seasoning — A process involving the reduction of moisture content in timber under more or less controlled conditions towards or to an amount suitable for the purpose for which it is to be used
Set — The amount of cut the teeth should be able to give clear of the body of the saw blade, so that there is freedom from



friction between saw blade and timber. This is achieved either by bending over to right or left the cutting point of alternate tooth or by increasing the thickness of the cutting point of the teeth from the thickness of the saw blade. The former is called spring set while latter is called swage set. In India generally spring set is used.

Shake — A partial or complete separation between adjoining layers of tissues as seen on the end surfaces.

Sharpness Angle — The angle between the front and the back of the saw teeth.

Shelf Life — The period for which the adhesive or adhesive components may be stored without affecting their suitability for use in accordance with the relevant standards.

Shrinkage — The reduction in dimensions of timber which takes place during drying.

Sizing Material — Alum, wax, resin or other additive introduced to the agglomerate for a particle board/ medium density fibreboard/medium density coirboard, etc, prior to forming, primarily to increase water resistance.

Sleeper — A piece of timber used as transverse support under rails in railway lines, usually square sawn.

Softwood — A conventional term used to denote the timber from conifers and has no relationship with the physical properties of hardness or strength. On account of the confusion this term can cause, its use is discouraged.

Sound Wood — Wood free from insect hole, rot, loose knot, dote and sound knot exceeding 2 mm in diameter.

Spacing Blocks — Any block or wood strip fastened to the inside of the crate to hold the contents in position.

Splints — Undipped match sticks prior to application of chemical head.

Split — A separation of fibres whichextends from one face of a piece of wood to another and runs along the grain of the piece.

Spring — Edgewise deviation from a straight line drawn from end to end of a piece.

Square — Timber formed by slabbing a log on four sides.

Steam Bending — Bending timber to the required shape with the help of steaming process.

Strain - The change in dimension in the direction of the force with respect to the original dimension. . As it the ratio of two dimensions, it has no unit.

Strength - Ability to sustain an external load.

Strength Coefficient — The numerical value for a timber species evaluated by taking into consideration relevant suitability indices for a particular end use expressed in terms of teak as 100.

Stiffness - Ability of a structure to resist deformation

Stress - Force per unit area and results when a member is subjected to a load. It is expressed in the unit of pound per square inch (psi) or Pascal (Pa).

Structural Timber — Timber used in framing and load bearing structure or timber used or intended for use in building where strength is the primary consideration.

Suitability Coefficient — A numerical value attached to a timber giving an idea about its suitability for particular purpose. Suitability coefficients are calculated from the physical and mechanical properties of the timber.

Surface Crack — Shallow longitudinal separation of the fibres which does not extend beyond a depth of 9.5 mm.

Swelling — Increase in size of sawn timber due to the increase of its moisture content.

Synthetic Resin — Amorphous organic materials produced by the polymerization or condensation of one, two or less frequently three relatively simple compounds. The term is also applied now-a-days to chemically modified natural resins. The properties of synthetic resins can vary widely depending upon their basic raw materials, proportions and conditions of manufacture. All synthetic resins are classified broadly as thermosetting or thermoplastic.

Tenon — A tongue like projection on the end of a piece of timber to fit into a corresponding mortise.

Tension Wood — Abnormal wood formed on the upper side of branches and inclined stems of broad-leaved trees, characterized by gelatinous fibres.

Test Area — A particular compartment/block of forest area selected for getting the timber trees for testing.

Testing Authority — The organization which is responsible for testing timber and presenting its data in accordance with the standard procedures.

Thermal Conductivity — It is defined as the quantity of heat which flows in one second across unit are of a slab of timber of unit thickness when the temperature of the faces of the slab differs by one degree. In SI units it is expressed in watt per metre Kelvin (W/mK).

Timber — A commercial wood, often in converted form.

Torn Grain — A rupture and lifting of the surface grain of the wood resulting in rough surface.

Trunk — The stem of a tree.

Twist — Spiral distortion of the piece lengthwise.

Veneer — A thin sheet of wood of uniform thickness obtained by slicing, rotary cutting or sawing.

Veneer Particle Boards — A particle board with one ply on each side.

Volume, Void — In wood, any space unoccupied by wood substance.

Wall Thickness — Half the difference between outer diameter and inner diameter of the piece at any cross-section.

Wane — The original rounded surface of a tree remaining on a piece of converted timber.

Warp — A deviation in sawn timber from a true plane surface, or distortion due to stresses causing departure from a true plane.

Weathering — Effect caused by exposure to weather.

Wood — Used in general sense, whether commercial or not.

MOISTURE CONTENT

Specimen shall be about 2.5 cm in length and of full section as the tested piece. In the case of shear test, the detached portion of the section 5 × 5 cm or 2 × 2 cm shall be taken for determination of moisture content. When only moisture content is to be determined the dimensions shall be taken as 2.5 cm in length and 2 × 2 cm or 5 × 5 cm in cross- section. The sample shall be weight with accuracy of 0.001 g in a weighing balance and then dried in a well-ventilated oven at temperature of 103 ± 2˚C. The weight shall be recorded at regular intervals. The drying shall be considered to be complete when the variation between last two weighings, does not exceed 0.002 g. The final weight shall be taken as oven dry weight.

Calculation: The loss in weight expressed as a percentage of the oven dry weight. shall be taken as the moisture content of the test specimen. The formula for calculation is given below.

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

Where,

W_1 = weight of sample at test in g, and

W_0 = oven dry weight of sample in g.

ESTIMATION OF SPECIFIC GRAVITY OF WOOD

Wood density or specific gravity of wood is considered as the single most important wood property contributing to wood quality. This has direct and significant positive correlation with pulp, paper and timber products, though the density and the specific gravity of wood are commonly used synonymously and refer to how much substance is present, these two are expressed as two different ways. Density is weight per unit volume, whereas, specific gravity is the ratio of the weight of a given volume of wood to the weight of an equal volume of water and is unit less.

The specimen shall be weighed correct to 0.001 g. The dimensions of rectangular specimen shall be measured correct to 0.01 cm and volume shall be calculated by multiplying all the three dimensions. The volume of irregular specimen shall be determined by mercury volumeter. The level of mercury in the volumeter shall be raised to the given mark on the capillary tube and reading shall be noted. The level shall then be brought down and specimen shall be inserted in the volumeter. After raising the level to the given mark, the reading shall be taken again. Care shall be taken that no air bubble is entrapped in the volumeter.

CALORIFIC VALUE OF WOOD

The heat generated by fuels when they burn in joules or calories measures quality of fuels. The heat liberated by the fuels varies and this can be distinguished in terms of number of joules or calories that they generate on burning. Wood has been traditionally used as fuel. The main content of wood is cellulose $(C_6H_{10}O_5)_n$. The presence of oxygen in a fuel helps oxidation but does not contribute to heat or its calorific value. Infact, it is seen that if a substance contains oxygen, it will produce less heat energy per unit weight when the substance burns. However, if carbon is present more heat is produced. In wood the percentage of carbon is quite less. This gives wood quite a less calorific value. Heat energy is measured in units of joules or calories (1calorie = 4.18 joules).

The amount of energy generated when 1unit mass of fuel is burnt completely is known as the calorific value of the fuel. The word calorific is used, not "joulific" because of the use of the word calorific has been in use for a very long time. When 1 gram of charcoal is burnt, it produces 33 kilo joules. Thus, the calorific value of charcoal is 33 kJ/g. Sometimes instead of calorific value, another term kilowatt per kilogram (KWh/kg) is used.

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 the rise in temperature of m grams of water when n grams of fuel are burnt completely.

There are many sources of error in the simple experiment. The table below shows how the errors can be minimized.

Type of Error	How to minimize the error
Heat lost to the surrounding is neglected	Enclose the colorimeter in insulating box
Heat lost by the beaker is neglected	Determine the thermal capacity of beaker and include it in equation
Incomplete or insufficient combustion of fuel in air	The fuel should be burnt in oxygen atmosphere and not in air

STANDARD SPECIMEN SIZES FOR EVALUATION OF MECHANICAL PROPERTIES

All strength data of timber are obtained mainly by testing by small clear specimens, also known as standard specimens because the most reliable comparison of different species is obtained only by testing pieces free from any types of defects and the expenses involved in collection of material, preparation of specimens and testing should be as low as possible without prejudice, however, to the securing of an acceptable average for the strength properties of the species as a whole. The data thus obtained should be capable of being used with adequate safety factors for design purposes, and also for establishing the suitability of various timbers for many industrial and domestic applications. With this in use, standard specimens of 5 x 5 cm cross section are now used in India, the length and shape of the specimens being, however, different for different mechanical and physical properties. It may be stated that while the methods of carrying out the tests are in general well standardized in many parts of the world, all the tests are not necessarily carried out a standard routine by the testing authorities. In India 11 mechanical and 6 physical tests are carries out as a routine on all species of timber using samples from different localities.

Mechanical test conducted on the timber specimen in India

S.No.	Mechanical test	Size of specimen	Surface on which load is applied
1.	Static Bending	5 x 5 x 75 cm on a span of 70 cm	Tangential surface near to the heart
2.	Impact bending	5 x 5 x 75 cm on a span of 70 cm	Tangential surface near to the heart
3.	Compression parallel to grain	5 x 5 x 20 on a gauge length of 15 cm	Tangential surface near to the heart
4.	Compression perpendicular to grain	5 x 5 x 15 cm	Cross section
5.	Indentation test (Hardness)	5 x 5 x 15 cm	Radial surface
6.	Shear	5 x 5 x 6.25 with a corner notch to produce a failure on 5 x 5 cm surface	Radial and tangential
7.	Tension perpendicular to grain	50 x 50 x 56 cm with semicircular notches for gripping so as to produce a failure on a 50 x 20 cm area in radial or tangential plane	One for radial one for tangential
8.	Tension parallel to grain	7 mm x 7mm cross section, cm gauge length shoulders and wide surface for gripping	Cross section
9.	Torsion	Cylindrical specimen of 25 mm dia gauge length 15 cm and grips of 30 cm x 30 cm x 40 cm at each end.	Cross sectional rotation
10.	Nail and screw pulling test	5 x 5 x 15 cm	Radial, tangential and end surface
11.	Brittleness	Izod test 22 mmx22 mmx125-150 mm	Cross section and tangential

Among the routine physical tests involves the determination of moisture content, specific gravity, radial, tangential and volumetric shrinkage and a few structural characteristics such as percentage of sapwood present width of the annual rings, interlocking in grain etc. While collecting the samples from the field, 10 logs of sound straight grained trees of merchantable size of average age are selected. Necessary information on the local conditions, such as soil, elevation, surroundings, usual climate, etc. should be noted. When the logs are received in the laboratory, their condition is recorded, necessary photographs are also taken for record and are marked to convert into scantlings or sticks for obtaining specimens for the various tests in green and dry conditions. All the even numbered sticks from the upper half of the log and the odd numbered sticks form the lower half of the log are sorted out for testing in green condition, the rest will be tested in the airdry condition. All sticks are to be tested under one required condition, bundled together are called as composite bolts.

DETERMINATION OF STATIC BENDING STRESS

The specimen for static bending test shall be 5 X 5 cm in cross-section and 75 cm in length or 2 X 2 cm in cross-section and 30 cm in length. The specimens shall be free from any defect and shall not have a slope of grain that 1 in 20 parallel to longitudinal edges.

The test shall be conducted on a suitable testing machine. The test specimen shall be so placed on a rig that the load is applied through a loading block to the tangential surface nearer to the heart. The specimen shall be supported on the rig in such a way that it will be quite free to follow the bending action and will not be restrained by friction. The bottom surface of the loading block shall be cylindrical, having radius equal to 75 cm in case of 5 X 5 cm cross-section and 30 mm in case of 2 X 2 cm cross-section specimen. Load shall be applied centrally on a span of 70 cm for 5 X 5 cm cross-section and 28 cm for 2 X 2 cm cross- section. Thin metal plate shall be placed between the loading, block and the specimen so as not to cause indentation.

The load shall be applied continuously throughout the test such that the movable head of the testing machine moves at a constant rate of 2.5 mm per minute in case of 5 X 5 X 75 cm and 1.0 mm per minute in case of 2 X 2 X 30 cm.

Measurement of Load and Deflection

a) Deflection of the neutral plane at the center of the length shall be taken with respect to the points in the neutral plane above the supports.
b) Deflections of the neutral axis shall be measured at the centre of the beam to the following accuracy either by a suitable deflectometer or by means of a dial gauf2e, or by telescope and scale:
Up to 30 mm correct to 0.02 mm
Over 30 mm correct to 0.2 mm
c) Deflection shall be measured at suitable load intervals such that about 8-10 readings are available up to limit of proportionality. Beyond the limit of proportionality up to maximum load or beyond maximum load as the case may be, the load and deflection shall he measured either at suitable intervals of load or of deflection. Beyond maximum load the test shall be continued until a deflection of 15 cm for 5 X 5 X 75 cm and 6 cm for 2 X 2 X 30 cm is reached or the specimen fails to support 100 kg for 5 X 5 X 75 cm or 20 kg for 2 X 2 X 30 cm, whichever is earlier.
d) The load and deflection at the first failure, the maximum load and the points of sudden changes in deflection and load shall be recorded even if they may not occur at any of the regular load or deflection increments.

The failure of the specimen shall be recorded according to its appearance and development.

The reading of deflection and the loads shall be recorded as explained above and a load-deflection curve shall be drawn. While drawing a load deflection curve, the following rules shall be adopted.

a) The straight line of proportionality shall be drawn in such a way that maximum number of points shall be on the straight line or nearest to it.
b) For the above purpose, the initial two or three points need not be given much importance.
c) When the straight line does not pass through the origin, a parallel line shall be drawn through the origin and the deflection and load at the limit of proportionality shall be measured on this line.
d) If a planimeter is used for finding the areas up to the maximum. Load or the final load, the planimeter, shall pass through the point where the load deflection curve actually ends and then extended in a line parallel to Y-axis until it cuts the abscisca.
e) The points beyond the elastic limit and up to maximum load may be connected by a smooth curve but the points beyond the maximum load shall be joined from point to point for evaluating total work.

DETERMINATION OF IMPACT BENDING STRENGTH

The specimen for impact test shall be 5 X 5 cm in cross-section and 75 cm in length or 2 X 2 cm in cross-section and 30 cm in length. The specimens shall be free from defects and shall not have a slope of grain more than 1 in 20 parallel to longitudinal edges.

The test shall be conducted on a suitable impact bending machine consisting of a mechanism to drop hammer from different heights and a specimen holder holding the specimen in such a way that the hammer may fall at the centre of the specimen and the specimen may remain free to move on the impact and follow bending action on the fixed span. The span shall be 70 cm in case of 5 X 5 X 75 cm and 28 cm in case of 2 X 2 X 30 cm specimens. The weight of the hammer shall be 25 kg and 1.5 kg for the two sizes respectively. The bottom surface of the hammer shall be cylindrical of radius 75 cm and 30 mm respectively. The impact shall be on the tangential surface nearer to heart. When necessary, for stronger species, heavier hammer of double the weight having the same cylindrical surface shall be used. In such cases the height shall be doubled for purpose of calculation.

Static deflection *(x)* due to the weight of the hammer shall be measured at the centre of the specimen to the nearest 0.02 mm by suitably placing the dial gauge under the specimen with hammer resting on the surface of the specimen.

For recording of deflection a drum shall be provided which can be brought in contact with a stylus attached to hammer and can be rotated on a vertical axis. On the drum a paper shall be fixed by means of sticking tape, under which a carbon paper shall be placed inverted for recording the impressions. First a datum line shall be marked by placing the hammer to rest on the specimen and rotating the drum with stylus touching it. After that the hammer shall be dropped from different heights and deflection recorded on the paper fixed on the drum. The first drop of hammer shall be from a height of 5 cm after which the height of successive drops shall be increased by 2-5 cm until a height of 25 cm is reached, and thereafter increment in height shall be 5 cm until complete failure occurs or 15 cm or 6 cm deflection is reached for the two sizes respectively.

Deflections due to successive drops arc recorded. For this purpose, at the drop of the hammer, the drum is to be rotated as the hammer rebounds.

The failure of the specimen shall be recorded according to its appearance and development as indicated.

Calculation: From the tracing on the drum record the actual deflection (y) at each drop (that is, the distance from the lowest point to the datum line) is measured with the help of a pair of dividers and diagonal scale to the accuracy of 0.1 mm.

A graph shall then be plotted with the exact height of drop plus maximum deflection at that drop H (x + y) as the ordinate and (y + x)2 as the abscissa. The point at which the curve deviates from a straight line shall be taken as limit of proportionality

DETERMINATION OF COMPRESSIVE STRENGTH PARALLEL TO GRAIN

The test specimen shall be 5 X 5 cm in cross-section and 20 cm in length or 2 X 2 cm in cross-section and 8 cm in length. The specimens shall be free from defects shall not have a slope of grain more than 1 in 20 parallel to longitudinal edges. The end planes of the specimen shall be perfectly at right angles to the length of the specimens.

The test shall be carried out on a suitable testing machine. At least one platen of the testing machine shall be equipped with a hemispherical bearing to obtain uniform distribution of load over the ends of the specimen. The specimen shall be so placed that the center of the movable head is vertically above the center of the cross-section of the specimen.

NOTE - It is essential that the ends of the rectangular test specimen are smooth and parallel and normal to the axis and that the testing machines are of such construction that the surfaces between which the test specimen is placed are parallel to each other and remain so during the whole period of test.

Rate of Loading - The load shall be applied continuously during the test such that the movable head of the testing machine travels at a constant rate of 0.6 mm per minute for both the sizes.

Measurement of Load and Deflection — For 5 X 5 X 20 cm specimen a load of 250 kg shall initially be applied to set the specimen. Deformation under compression shall then be measured correct to 0.002 mm by means of a suitable compressometer over a central gauge length of 15 cm. Where possible direct points shall be obtained on a graph sheet. The reading shall be continued well beyond the proportional limit. The final reading at the maximum load shall be recorded. It would be preferable to remove the compressometer before the maximum load. The deformation shall be read at suitable load intervals such that 8 to 10 readings are obtained before limit of proportionality is reached. For 2 X 2 X 8 cm specimen final reading of the maximum load shall only he recorded. In case deformation, readings are also required for evaluation modulus of elasticity under compression the same shall be recorded correct to 0.01 mm by means of a dial gauge. The deformation shall be read at suitable load intervals such that 10 to 15 reading area obtained before proportional limit is reached. If required a load not more than 20 kg shall initially be applied to set the specimen.

To obtain satisfactory and uniform results the failure may be made to develop on the body of the specimen by continuing the machine to run a longer time. Compression failures shall be recorded according to the appearance of the fractured surface. In case two or more kinds of failures develop, they shall be described in the order of their occurrence.

DETERMINATION OF COMPRESSIVE STRENGTH PERPENDICULAR TO GRAIN

The test specimen shall be 5 X 5 cm in cross-section and 15 cm in length or 2 X 2 cm in cross-section and 10 cm in length. The specimens shall be free from defects shall and faces hall approach closely to the true radial and tangential direction.

The test shall be carried out on a suitable testing machine. The load shall be • applied continuously throughout the bearing plate 5 cm in width of at least 15 mm thickness placed centrally across the upper surface of the specimen at equal distances from the ends at right angles to the length. The load shall be applied to the radial surface.

The load shall be applied continuously during the test such that the movable head of the testing machine travels at a constant rate of 0.6 mm per minute for both the sizes.

At small load not more than 50 kg on 5 X 5 X 15 cm and 10 kg on 2 X 2 X10 cm specimen shall initially be applied to set the specirrica. The deformation then shall be measured correct to 0.02 mm by means of dial gauge or mirror and scale technique at suitable load intervals so that 8 to 10 reading are available up to limit of proportionality and is continued up to deformation of 2.5 mm. If a maximum load is reached at some lesser value of compressive deformation, the same shall be recorded along with corresponding deformation.

A curve between load and deformation shall be drawn observing the rules explained above. The load and deformation at limit of proportionality is then read. Load at 2.5 mm compression shall also be recorded.

DETERMINATION OF SHEAR STRENGTH PARALLEL TO GRAIN

The test specimen shall be 5 X 5 cm in cross-section and 6 cm in length or 2 X 2 cm in cross-section and 3 cm in length. The specimens shall be notched on one side to produce shear failure on 5 X 5 cm or 2 X 2 cm surface in the radial or tangential plane.

The test shall be carried out on a suitable testing machine with help of a shearing tool in a rig. The specimen shall be supported in the rig by means of a cross bar such that the edges of the specimen are vertical and part of end surface not to be sheared off rests on the support throughout the test. The shearing tool shall rest on the notch. The direction on shearing shall be parallel to the longitudinal direction.

The load shall be applied continuously during the test such that the movable head travels at a constant rate of 0.4 mm per minute.

The maximum load required for shearing the area shall be recorded. The load divided by the area gives the maximum shearing stress (MSS) in the concerned plane (redial or tangential) for both sizes.

For the purpose of comparison of maximum shearing stress parallel to grain (average of radial and tangential), the ratio of the results of 5 X 5 cm and 2 X 2 cm cross-section shall be taken as 0.87.

DETERMINATION OF TENSILE STRENGTH PERPENDICULAR TO GRAIN

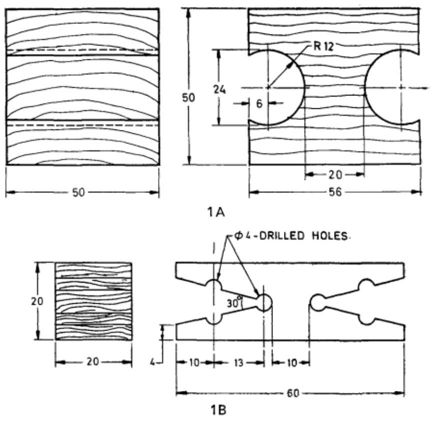
The test specimen for the two sizes shall have the shape and size in such a way that the sample shall be notched in the centre part giving it a circular cut. The cross-section of the central portion of the specimen shall be 7 X 7 mm or 5 X 5 mm for the specimen. The gauge length shall be 5 cm and 3 cm for the two sizes respectively. The annual rings on the ends shall be perpendicular to the greater cross sectional dimension in case specimen.

The test shall be conducted on any testing machine provided with suitable types of grips to hold the specimen firmly without any slip during the test. The specimen shall be held firmly in the grips and the suitable elongation measuring device shall be attached to the gauge length.

The load shall be applied continuously during the test such that the movable head travels at a constant rate of one millimeter per minute for both sizes.

Elongation shall be measured correct to 0.002 mm at suitable load intervals such that 8-10 readings and available up to limit of proportionality. Readings shall be continued well beyond the proportional limit and the final reading of load at failure shall be recorded. It would be preferable to remove the elongation measuring device before the maximum load is reached.

Load elongation curves shall be drawn observing the rules explained above. Load -and elongation at proportional limit shall then be read.



DETERMINATION OF TENSILE STRENGTH PERPENDICULAR TO GRAIN

The test specimen for the two sizes shall have the shape and size by preparing the notches shown in Fig. 1 A and 1B as to produce a failure on 50 X 20 cm mm area or 20 X 10 mm area in the radial or tangential surface as desired.

The test shall be conducted on a testing machine provided with suitable grips to hold the specimen. These grips shall have cushioning springs for prevention of damage to the machine when the specimen suddenly breaks. The specimen shall be placed in the grips.

The load shall be applied continuously throughout the test so that the movable head moves at a constant rate of 2.5 mm per minute until the maximum load is reached for both sizes.

The maximum load required for perpendicular to grain shall be recorded. The load divided by the area gives the maximum tensile stress perpendicular to grain in the concerned plane (radial or tangential).

DETERMINATION OF NAIL AND SCREW HOLDING POWER

The test specimen shall be 5 X 5 cm in cross-section and 15 cm in length. Where this cross-section is not available, sticks of 2 X 2 cm or more in cross-section shall be glued together to make the cross-section of at least 4 X 4 cm. Care shall he taken that the grain direction may be same in all the glued sticks of the specimen' The length shall however be 15 cm.

Nail shall be 50 mm long of 2.50 mm shank diameter and shall he bright, galvanized, diamond pointed and shall have plain heads. Each nail shall be used only once. Screws shall be No.8 (IS : 451-1961*) shall be galvanized gimlet pointed. The length shall be 50 mm. Each screw shall be used only once.

Nail and screws as specified above shall be driven exactly at right angle to the face of the specimen to a total penetration of 25 mm. In the case of screws, a pre bore 2.5 in diameter shall be made. In each specimen, the nail and one screw on both the radial as well as tangential surface and one nail on one end and one screw on the other end. On radial and tangential surfaces the nails and screws shall be driven at a distance not less than 35 mm from the ends and 12 mm from the edges. Nails and screws shall not be driven in a line parallel to the length of the specimen or less than the projected length of 50 mm apart. At the ends, the screw or nails shall be in the centre. In the case of glued specimen care shall be taken that the nails or screws may not be driven on the glue line.

The test shall be conducted on a testing machine provided with a suitable device to grip the test price to the fixed head and the nail or screw to the movable head of the machine. The specimen prepared as mentioned above and shall be held firmly on the machine, with the nail or screw gripped in gripping device.

The load shall be applied continuously throughout the test so that the movable head moves at a constant rate of 2 mm per minute until the nail or screw is pulled out completely. The maximum load required to pull out the nails or screws shall be recorded for radial, tangential and end surfaces. The average vaules for radial and tangential surfaces shall be taken as 'side values'.

VOLUMETRIC SHRINKAGE

The specimen shall be weighed initially (usually green) correct to 0.001 g and the volume shall be determined by immersion method correct to 0.01 cc. A suitable vessel, half filled with water, shall be kept on the pan of a weighing balance and weighed correct to 0.001 g. The specimen shall be then completely dipped in water by means of a needle and weighed again. Care shall be taken that no air bubble sticks to the specimen and the specimen may not touch the vessel. The difference of the two readings shall be volume of the specimen. The specimen shall be taken out from water wiped with dry cloth and end-coated by immersion in hot paraffin and allowed to air-season under room conditions and weighed periodically until moisture content of about 12 percent is reached. The volume shall again be determined by method. The specimen shall then be kept in an oven at 103±2°C until an approximately constant weight is reached. After oven-drying, the specimen shall again be weighed and, while still warm, shall be immersed in hot paraffin-wax bath, care being taken to remove it quickly to ensure only a thin coating. The volume of the paraffin-coated specimen shall be determined by immersion as before.

NON-DESTRUCTIVE TESTING OF TIMBER

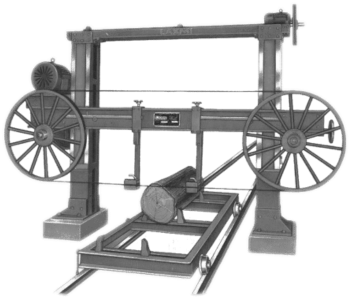
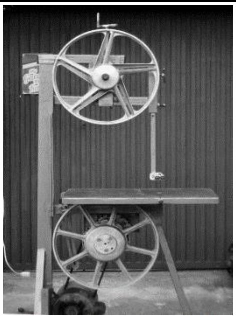
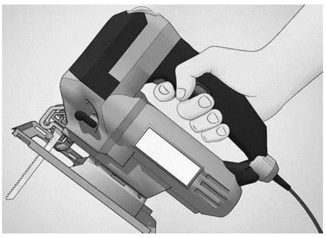
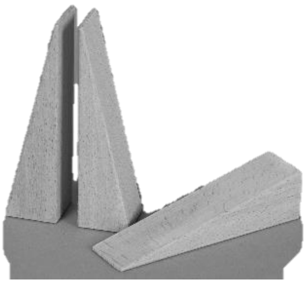
Importance: The normal testing methods which have been described in earlier chapter involves the breakdown of the timber specimen, therefore same specimen becomes unfit for retesting or other use. Other drawbacks of destructive testing are:

a. Repeated test for evaluation of different properties of the same specimen are not possible.
b. Material in-situ built up structure is not possible. Therefore, there is need to adopt method of non-destructive testing of timber.

Methods of non- destructive testing:-

a. Resonance frequency method (RFM)
b. Ultrasonic transmission method (UTM)

WOOD CUTTING INSTRUMENTS

		
Horizontal Band Saw	Vertical band Saw	Combiner
		
Cross Cutting Saw	Hand Jig Saw	Belt Sander
		
Power Chain Saw	Hand Saw	Frame Saw
		
Bow Saw	Axe	Chisel
		
Wedge	Hand drill	Stand drill

TIMBER JOINERY

Joinery is the method by which different piece of wood are attached and is often an indication of the quality of piece of furniture. Some common type of joints used in various application are given below:

Butt joint	Metter joint	Spline joint
Lap joint	Mortise and Tenon joint	Tongue and groove joint
Dado joint	Scarf joint	Doweled joint
Dovetail joint		

Butt joint: A butt joint is a simple method of connecting two pieces of wood with the square end of one piece being placed against the side of the another. The two pieces form a right angle and are joined by a nail, screws or a dowel.

Cross Lapped joint: A rectangular section is cut out of each to two pieces of wood that are to be joined.

Dado joint: A dado joint connects two pieces of wood by cutting a groove in one piece of wood which is equal to the width of the second piece. The second piece is then inserted in to the groove.

Dovetail joint: In dovetail joint, connect two pieces of wood by flaring the ends of one piece to conform to the shape which is cut out of the second piece. If the end of the flared piece does not extent all the way through the second piece. It is an invisible joint called a stopped or lapped dovetail joint.

Doweled joint: Small holes are cut in to two pieces of wood at equal distances. They are then joined by inserting small, round pegs in to the wholes of each piece, so that they line up with the piece to be joined. The pieces are then glued.

Miter joint: The pieces of wood are cut a 45° angle and the two beveled edges are placed end to end. They are usually connected by glue, nail or screws.

Mortise and Tenon joint: Mortise is a shaped recess and tenon is a curved projection, usually rectangular. The tenon is inserted in to the mortise in same way a peg is inserted in to a hole. The pieces are generally secured by drilling a hole through the two pieces and inserting a dowel. It is one of most common joints used for joining the rail and legs of table, chairs and other type of furniture's. The strength of the mortise and tenon joint depends entirely on the interplay between the check and shoulder of the tenon, which is the projecting part of the joint.

Scarf joint: Two pieces of wood are joined by tow metal plates with hole. The two pieces of wood are place end to end and the plates are placed on each piece of wood. The plates are then attached to the wood by nails or screws.

Spline joint: Grooves are cut in the ends of each strip of wood called a spline in inserted into each groove to join two pieces of wood.

Tongue and groove: Two pieces are joined by cutting an edge or shape on one piece of wood which fits into a groove cut in the other. The tongue and the groove must be equally cut.

JOINTS USING MECHANICAL FASTENERS

- Construction of wood/timber-framed houses is quite common in many countries due to local availability of the materials in abundance.
- Fence posts, tent poles, bridges, bullock cart and to some extent in agricultural implements.
- In the field of construction particularly in low cost housing applications not much attention has been paid.
- The use of poles as structural material in trusses, rafters, and columns has gained importance recently in India because of so many frequent earthquakes, coastal cyclonic problems and other natural calamities.
- A wood structure's capacity to resist externally applied forces depends not only on the quality of the timber but mainly on the joints because it is the weakest point.
- Connecting the load bearing poles together is one of the most important problems. Structural integrity of any frame depends upon the efficiency of the joints rather than on member sections, being the weakest link in the section.
- Failure of wood buildings; 90% of failure occur in the vicinity of the connections. (Because connection is an area of high stresses)
- As joints are a source of weakness in any wooden pole structure, they must be made as strong and rigid as possible.