भारतीय मानक

निर्माण कार्यों में संरचनात्मक इमारती लकड़ी के डिजाइन — रीति संहिता

(चौथा पुनरीक्षण)

Indian Standard

DESIGN OF STRUCTURAL TIMBER IN BUILDING — CODE OF PRACTICE

(Fourth Revision)

First Reprint JULY 1995

UDC 691·11 : 624·011·1 : 624·04

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

August 1994

Price Group 7

FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

This Indian Standard was first published as code of practice for use of structural timber in building (material, grading and design) in 1957 and was first revised in 1961. In the second revision in 1966, clauses relating to specification and grouping of structural timber were deleted and these aspects were covered in detail in a separate standard, namely IS 3629 : 1966 'Specification for structural timber in building which was subsequently revised in 1986. The third revision of this standard took place in 1970. This is the fourth revision of the standard. In this revision besides taking into account the revised version of IS 3629:1986 'Specification for structural timber in building (*first revision*)' and strength data on additional species, the experience gained during the past years in using the standard, has also been considered. The different species of timber available in the country which have been tested so far and found suitable for construction purposes have been classified into three main groups based on modulus of elasticity and modulus of rupture. The design of deep and built-up beams and spaced columns are covered in detail. Safe working stresses of recommended species and their relevant pertinent data given in this standard have largely been derived from publications of Forest Research Institute, Dehra Dun.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

This standard is one of the two Indian Standards on structural timber in building. The other standard being IS 3629 : 1986.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESIGN OF STRUCTURAL TIMBER IN BUILDING — CODE OF PRACTICE

(Fourth Revision)

1 SCOPE

1.1 This standard covers the general principles involved in the design of structural timber in buildings.

1.2 The following aspects are not covered in this standard:

a) Timber pile foundations;

b) Structural use of plywood;

c) Design of structural timber joints and fastenings;

d) Lamella arch roofing; and

e) Timber-concrete composite construction.

2 REFERENCES

2.1 The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 707 : 1976 and IS 3629 : 1986, and the following shall apply.

3.1.1 *Box Column*

A column formed of four members having a hollow core. Members are joined with one another forming a box and provided with solid block at ends and intermediate points.

3.1.2 *Fundamental or Ultimate Stress*

The stress which is determined on small clear specimen of timber, in accordance with standard practice and does not take into account the effect of naturally occurring characteristics and other factors.

3.1.3 *Permissible Stress*

Stress obtained after applying factor of safety to the ultimate stress.

3.1.4 *Purlin*

A roof member directly supporting roof covering or rafter and roof battens.

3.1.5 *Solid Column*

Solid columns are formed of any-section having solid core throughout.

3.1.6 *Spaced Column*

Spaced columns are formed of two or more members jointed at their ends and intermediate points by block pieces

3.1.7 *Working Stress*

Stress obtained after applying necessary adjustment factors (according to the particular design) to the permissible stress.

4 SYMBOLS

For the purpose of this code, the following letter symbols shall have the meaning indicated against each:

A = area of cross-section of column in mm²

b = breadth of beam in mm

C = concentrated load in N

D = depth of beam in mm

D_1 = depth of beam at notch in mm

D_2 = depth of notch in mm

d = dimensions of least side of column in mm

d_1 = the least overall width of box column in mm

d_2 = the least overall dimension of core in box column in mm

E = modulus of elasticity in bending in N/mm²

e = length of the notch measured along the beam span from the inner edge of the support to the farthest edge of the notch in mm

f_{ab} = calculated bending stress in extreme fibre in N/mm²

f_{ac} = calculated average axial compressive stress in N/mm²

f_{at} = calculated axial tensile stress in N/mm²

f_b = the permissible bending stress on the extreme fibre in N/mm²

f_c = permissible stress in axial compression in N/mm²

f_{cn} = permissible stress in compression normal (perpendicular) to grain in N/mm²

f_{cp} = permissible stress in compression parallel to grain in N/mm²

$f_c\theta$ = permissible compressive stress in the direction of the line of action of the load in N/mm²

f_t = permissible stress in tension parallel to grain in N/mm²

H = horizontal shear stress in N/mm²

I = moment of inertia of a section in mm⁴

K = coefficient in deflection depending upon type, criticality of loading on beam

K_1 = modification factor for change in slope of grain

K_2 = modification factor for change in duration of loadings

K_3,
K_4,
K_5
and
K_6 = form factors

K_7 = modification factor for bearing stress

K_8 = constant equal to $0{\cdot}584\sqrt{\frac{E}{f_{cp}}}$

K_9 = constant equal to $\frac{\pi}{2}\sqrt{\frac{U \times E}{5_q f_{cp}}}$

K_{10} = constant equal to $0{\cdot}584\sqrt{\frac{2{\cdot}5E}{f_{cp}}}$

l = span of beam or truss in mm

M = Maximum bending moment in beam in N/mm²

n = shank diameter of the nail

p_1 = ratio of the thickness of the compression flange to the depth of the beam

Q = statical moment of area above or below the neutral axis about neutral axis in mm³

q = a constant for particular thickness of plank

q_1 = ratio of the total thickness of web or webs to the overall width of the beam

S = unsupported overall length of column in mm

t = nominal thickness of planks used in forming box type column in mm

U = constant for a particular thickness of plank

V = vertical end reaction or shear at a section in N

W = total uniform load

x = distance in mm from reaction to load

Z = section modulus of beam in mm³

Υ = a factor determining the value of form factor K_4

θ = angle of load to grain direction

δ = deflection at middle of beam

5 MATERIAL

5.1 Species of Timber

The species of timber recommended for constructional purposes are given in Table 1.

5.1.1 *Grouping*

Species of timber recommended for constructional purposes are classified in three groups on the basis of their strength properties, namely, modulus of elasticity (E) and extreme fibre stress in bending and tension (f_b). The characteristics of these groups are given below:

Group A — E above $12{\cdot}6 \times 10^3$ N/mm²; f_b above 18·0 N/mm²

Group B — E above $9{\cdot}8 \times 10^3$ N/mm² and up to $12{\cdot}6 \times 10^3$ N/mm²; f_b above 12·0 N/mm² and up to 18·0 N/mm²

Group C — E above $5{\cdot}6 \times 10^3$ N/mm² and up to $9{\cdot}8 \times 10^3$ N/mm²; f_b above 8·5 N/mm² and up to 12·0 N/mm²

5.1.2 Safe permissible stresses for the species of timber (classified into there groups in **5.1.1**) are given in Table 1.

5.1.3 Timber species may be identified in accordance with good practice.

5.2 Other general characteristics like durability, treatability of the species are given in Table 1, as far as these are known.

The species of timber other than those given in Table 1 may be used provided the basic strength properties are determined and found in accordance with **5.1.1**.

Other species can be used at the risk of larger sections and economy.

NOTE — For obtaining basic stress figures of the unlisted species, a reference may be made to the Forest Research Institute, Dehra Dun.

5.3 Moisture Content in Timber

Unless otherwise specified the moisture content of the timber shall conform to the requirements given in IS 287 : 1993 (*see also Table 2 for recommended moisture content based on the zonal division of the country*).

Table 1 Safe Permissible Stresses for the Species of Timber

[*Clauses* 5.1, 5.1.2, 5.2, 5.7.1, 5.7.2 (b) 6.2, 6.3, 6.4.1, 6.4.2, 6.4.2.2, 7.5.8.4 (b)]

Species		Locality From Where Tested	Average Unit Mass at 12 Percent Moisture Content	Modulus of Elasticity (All Grades and All Locations)	Permissible Stress in N/mm² for Grade I											Preservative Characters		§Refractoriness to Air Seasoning
					Bending and Tension Along Grain, Extreme Fibre Stress			Shear All Locations		Compression Parallel to Grain			Compression Perpendicular to Grain			†Durability Class	‡Treatability Grade	
Botanical Name	Trade Name		kg/m³	N/mm²	Inside Location	Outside Location	Wet Location	Horizontal	Along Grain	Inside Location	Outside Location	Wet Location	Inside Location	Outside Location	Wet Location			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
GROUP A																		
Acacia catechu	Khair	U. P.	1 009	134·4	20·1	16·8	13·4	1·55	2·21	13·8	12·3	10·1	7·7	6·0	4·9	I	—	A
Acacia chundra	Red kutch	M. P.	1 086	167·9	26·5	22·0	17·6	2·24	3·20	17·9	15·9	13·0	10·9	8·4	6·9	—	—	A
Albizia odoratissima	Black siris	Madras	737	135·4	18·7	15·6	12·5	1·53	2·19	13·3	11·8	9·6	7·3	5·6	4·6	I	e	B
Bruguiera spp.	Bruguiera (Mangrove)	Andmans	897	176 8	21·9	18·3	14·6	1·18	1·69	14·3	12·7	10·4	5·5	4·3	3·5	III	—	—
Grewia tiliifolia	Dhaman	Madras	788	148·2	18·3	15·2	12·2	1·31	1·87	12·0	10·7	8·7	6·0	4·7	3·8	II	d	B
Hopea utilis (*Balano carpus utilis*)	Karung	Madras	987	169·1	25·1	20·9	16·7	1·51	2·16	16·4	14·6	11·9	9·3	7·3	5·9	—	—	—
Hopea glabra	Hopea	Madras	1 081	147·9	21·3	17·8	14·2	1·53	2·19	14·5	12·9	10·6	9·9	7·7	6·3	I	—	A
Hopea parviflora	Hopea	Madras	923	130·3	18·6	15·5	12·4	1·29	1·84	13·2	11·8	9·6	9·2	7·3	6·0	I	e	A
Manilota polyandra (Syn. *Cynometra polyandra*)	Ping	Assam	903	132·0	19·1	15·9	12·7	1·28	1·84	1·17	10·4	8·5	5·7	4·4	3·6	III	b	A
Mesua ferrea	Mesua	Assam	965	163·0	23·3	19·4	15·5	1·23	1·76	15·5	13·8	11·3	5·9	4·6	3·7	I	e	A
Mimusops littoralis	Bullet-wood	S. Andaman	1 103	173·9	22·7	18·9	15·1	1·47	2·10	14·2	12·7	10·4	11·3	8·8	7·2	I	—	A
Pocciloneuron indicum	Ballagi	Madras	1 139	162·9	22·4	18·7	15·0	1·53	2·18	14·7	13·1	10·7	8·7	6·8	5·5	I	e	A
Pterocarpus Scantalinus	Red sanders	Madras	1 121	127·3	25·0	20·9	16·7	1·74	2·48	18·1	16·1	13·2	11·8	9·2	7·5	—	—	A
Sageraea elliptica	Chooi	Andaman	869	150·6	21·5	17·9	14·3	1·05	1·50	12·5	11·1	9·1	5·3	4·1	3·4	—	—	A
Stereospermun celonoides	Padri	Madras	731	129·4	19·0	15·8	12·7	1·12	1·60	11·9	10·6	8·7	4·0	3·1	2·6	III	—	B
Vitex altissima	Milla	Maharashtra	937	130·1	18·2	15·2	12·1	1·17	1·67	12·6	11·2	9·2	9·5	7·4	6·1	I	—	A
GROUP B																		
Albizzia lebbeck	Kokko	Andaman	642	111·7	13·4	11·2	9·0	1·08	1·54	9·0	8·0	6·5	4·4	3·4	2·8	I	e	B
Anogeissus latifolia	Dhaura, Axle wood (Bakli)	U. P.	892	105·5	16·1	13·4	10·7	1·11	1·59	9·1	8·1	6·6	4·7	3·7	3·0	I	e	A
Artocarpus hirsutus	Aini	Madras	600	104·5	15·0	12·5	10·0	0·74	1·05	10·4	9·2	7·5	3·3	2·6	2·1	I	—	B
Acacia nilotica	Babul	U. P.	797	—	—	12·9	10·3	1·44	2·06	8·9	7·9	6·4	5·2	4·0	3·3	II	b	B
Acacia ferruginea	Safed khair	Maharashtra	993	122·8	23·0	19·2	15·3	1·65	2·35	13·9	12·4	10·1	9·9	7·7	6 3	—	—	—
Acrocarpus fraxinifolius	Mundani	Madras	690	125·9	16·1	13·4	10·8	1·23	1·76	10·5	9·4	7·7	4 6	3·6	2·9	III	c	B
Aglaia edulis	Aglaia	Assam	815	125·6	18·2	15·2	12·1	1·41	2·02	10·1	8·9	7·3	4·4	3·4	2·8	—	—	A
Anogeissus acuminata	Yon	Orissa	844	116·7	17·6	14·7	11·7	1·27	1·80	10·8	9·6	7·9	5·1	4·0	3·3	—	—	A
Atalantia monophylla	Jungli-nimbu	Orissa	897	103·1	16·7	13·9	11·1	1·47	2·10	11·3	10·0	8·2	6·3	4·9	4·0	—	—	—
Altingia excelsa	Jutili	Assam	795	113·7	17·1	14·3	11·4	1·17	1·81	11·0	9·8	8·0	6·8	5·3	4·4	II	e	A
Amoora spp.	Amari	Bengal	625	10·5	13·4	1·1	9·2	0·90	1·30	8·4	7·4	6·0	3·7	2·9	2·4	II	—	B
Bucklandia populnea (Syn. *Exbucklandia populnea*)	Pipli	W. Bengal	672	98·9	12·8	10·7	8·6	1·05	1·49	7·9	7 0	5·7	3·5	2·7	2·2	—	—	C
Cassia fistula	Amaltas	U. P.	865	118·0	19·2	16·0	12·8	1·43	2·04	12·3	10·9	8·9	7·2	5·6	4·6	I	—	A
Catallia lucida	Maniawaga	Assam	748	126·0	18·4	15·3	12·3	1·23	1·74	11·4	10·1	8·3	5·9	4·6	3·8	—	—	—
Canarium strictum	Dhup	Madras	655	118·6	13·3	11·1	8·9	0·86	1·23	8·1	7·2	5·9	2·8	2·2	1·8	III	—	C
Cassia siamea	Kasod	M. P.	820	105·0	15·4	12·8	10·9	0·98	1·39	10·8	9·6	7·9	5·5	4·3	3·5	—	—	—
Casuarina equisetifolia	Casuarina	Orissa	769	114·4	14·6	12·2	9·8	1·27	1·81	8·2	7·3	5·9	4·0	3·1	2·5	III	e	A
Colophyllum tomentosum	Poon	Maharashtra	657	97·7	13·4	11·2	9·0	0·79	1·12	8·6	7·7	6·3	2·8	2·2	1·8	II	—	B
Chloroxylon swietenia	Satin wood	M. P.	865	116·9	18·2	15·1	12·1	1·37	1·96	10·9	9·7	8·0	6·3	4·9	4·0	III	—	A
Cullenia rosayoana (Syn. *C. excelsa*)	Karani	Madras	625	124·3	14·7	12·3	9·8	0·64	0·91	9·0	8·0	6·6	2·7	2·1	1·7	III	b	C

(*Continued*)

Table 1 (*Continued*)

Species		Locality From Where Tested	Average Unit Mass at 12 Percent Moisture Content	Modulus of Elasticity (All Grades and All Locations)	Permissible Stress in N/mm² for Grade 1										Preservative Characters		§Refractariness to Air Seasoning
					Bending and Tension Along Grain, Extreme Fibre Stress			Shear All locations		Compression Parallel to Grain			Compression Perpendicular to Grain					
Botanical Name	Trade Name				Inside Location	Outside Location	Wet Location	Horizontal	Along Grain	Inside Location	Outside Location	Wet Location	Inside Location	Outside Location	Wet Location	†Durability Class	‡Treatability Grade	
			kg/m³	N/mm²														
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Diploknema butyracea (Syn. *Bassia butyracea*)	Hill mahua	S. Andaman	780	106·4	15·3	12·8	10·2	1·03	1·48	9·9	8·8	7·2	6·6	5·2	4·2	—	—	—
Dysoxylum malabaricum	White cedar	Madras	745	109·2	13·2	11·0	8·8	0·99	1·41	8·0	7·1	5·8	3·1	2·4	1·9	I	—	B
Dipterocarpus grandiflorus	Gurjan	N. Andaman	758	117·1	12·5	10·5	8·4	0·77	1·10	7·9	7·1	5·8	2·7	2·1	1·7	—	—	B
Dipterocarpus macrocarpus	Hollong	Assam	726	133·4	14·5	12·0	9·6	0·75	1·06	8·8	7 9	6·4	3·5	2·7	2·2	III	a	B
Dichopsis polyantha (Syn. *palaquium polyanthum*)	Tali	Assam	734	112·4	14·9	12·4	10·0	1·11	1·59	9·9	8·8	7·2	4·7	3·7	3·0	—	—	B
Dichopsis elliptica (Syn. *Palaquium ellipticum*)	Pali	Madras	606	118·6	13·9	11·6	9·3	0·72	1·03	8·5	7·5	6·2	2·9	2·2	1·8	II	e	B
Diospyros microphylla	Ebony	Maharashtra	776	121·5	14·2	11·9	9·5	0·91	1·29	8·3	7·3	6·0	3·3	2·6	2·1	—	—	A
Diospyros pyrrhocarpus	Ebony	N. Andaman	843	99·3	13·5	11·2	9·0	0·98	1·40	7·9	7·0	5·7	4·0	3·1	2·5	III	—	A
Dipterocarpus bourdilloni	Gurjan	Kerala	699	127·1	13·6	11·3	9·0	0·71	1·02	7·8	6·9	5·7	2·5	1·9	1·6	—	—	B
Eucalyptus globulus	Eucalyptus (Blue gum)	Madras	912	148·3	15·9	13·2	10·6	10·3	1·48	9·0	8·0	6·5	3·4	2·6	2·1	I	e	A
Eucalyptus eugenioides	Eucalypus	Madras	853	114·7	16·4	13·6	10·9	1·22	1·74	11·3	10·0	8·2	7·6	5·9	4·8	—	—	—
Eugenia gardnery	Jaman	Madras	952	119·4	14·8	12·3	9·8	1·14	1·62	9·2	8·2	6·7	5·8	4·5	3·7	III	d	—
Eugenia jambolana	Jaman	U. P.	778	109·4	16·0	13·3	10 6	1·21	1·73	9·7	8·6	7·1	4·7	3·7	3·0			
Gluta travancorica	Gluta	Madras	726	127·3	13·5	11·3	9·0	0·91	1·30	9·0	8·0	6·6	4·0	3·1	2·5	I	—	A
Grewia vestita	Dhaman	W. Bengal	758	120·0	15·4	12·6	10·3	1·37	1·95	9·1	8·1	6·6	4·1	3·2	2·6	II	d	B
Heritiera spp.	Sundri	Assam	872	133·7	17·9	14·9	11·9	1·27	1·81	11·0	9·8	8·0	6·5	5·0	4·1	I	—	A
Kingiodendron pinnatum (Syn. *Hardwickia pinnata*)	Piney	Madras	617	106·2	13·2	11·0	8·8	0·88	1·26	8·2	7·3	6·0	2·9	2·2	1·8	—	—	B
Kayea floribund	Karal	Assam	813	108·8	16·8	14·0	1·12	1·10	1·57	10·1	9·0	7·3	4·4	3·4	2·8	III	—	—
Lagerstromia lanceolata	Benteak	Madras	617	107·6	12·7	10·6	8·5	0 84	1·20	8·2	7·3	5·9	3·4	2·6	2·2	I	e	B
Lagerstromia parviflora	Lendi	U. P.	734	109·7	14·3	11·9	9·5	1·09	1·55	8·7	7·7	6·3	3·7	2·9	2·4	II	e	A
Mimusops elengi	Bakul	Madras	885	123·9	17·3	14·4	11.5	1·27	1·81	11·0	9·8	8·0	5·6	4·3	3·6	I	—	A
Machilus macrantha	Machilus	W. Bengal	692	100·0	12·4	10·3	8 3	1·03	1·47	8·2	7·3	6·0	3·5	2·7	2·2	—	e	B/C
Miliusa tomentosa (Syn. *Saccopetalum tomentosum*)	Hoom	Maharashtra	745	110·6	14·8	12·3	9·9	0 93	1·32	9·7	8·6	7·0	3 5	2·7	2·2	III	—	B
Pommetia pinnata	—	Andaman	788	129·0	14·3	11·9	9·5	1·09	1·56	9·1	8·0	6·6	4·0	3·1	2·5	—	—	—
Pterocarpus dalbergioides	Padauk	N. Andaman	721	112·4	17·1	14·3	11·4	1·02	1·46	12·0	10·7	8·7	5·5	4·3	3·5	I	c	B
Mesua assamica	Kayea	Assam	842	128·3	17·4	14·5	11·6	0·97	1·38	11·7	10·4	8·5	5·3	4·1	3·3	II	e	—
Pterocarpus marsupium	Bijasal	Maharashtra	803	102·5	14·9	12·4	9·9	0·94	1·34	9·1	8·1	6·6	4·1	3·2	2·6	I	e	B
Fraxinus macrantha	Ash	U. P.	712	106·9	15·0	12·5	10·0	1·22	1·74	8·5	7·6	6·2	4·3	3·3	2·7	III	—	B
Fraxinus excelsior	Ash	Punjab	719	104·1	14·8	12·3	9·8	1·17	1·67	8·1	7·2	5·8	3·3	2·6	2·1	III	—	B
Planchonia valida (Syn *P. andamanica*)	Red bombwe	Andaman	913	131·0	16·1	13·4	10·7	0·95	1·36	10·8	9·6	7·9	4·9	3·8	3·1	III	—	—
Quercus lamellosa	Oak	W. Bengal	87·0	124·4	14·5	12·1	9·7	1·15	1·65	8·7	7·8	6·4	3·8	2·9	2·4	II	c	A
Quercus griffithii	Oak	Meghalaya	974	100·6	13·1	10·9	8·8	1·11	1·59	8·0	7·1	5·8	4·6	3·6	2·9	—	—	A
Quercus incana	Oak	Punjab	1 008	108·2	15·8	13·1	10·5	1·22	1·76	8·7	7·8	6·3	5·0	3·9	3·2	—	—	A

(*Continued*)

Table 1 (*continued*)

Species		Locality From Where Tested	Average Unit Mass at 12 Per-cent Moisture Content	Modulus of Elasticity (All Grades and All Locations)	Permissible Stress in N/mm² for Grade I										Preservative Characters		§Refractoriness to Air Seasoning
					Bending and Tension Along Grain, Extreme Fibre Stress			Shear All Locations		Compression Parallel to Grain			Compression Perpendicular to Grain			†Durability Class	‡Treatability Grade	
Botanical Name	Trade Name		kg/m³	N/mm²	Inside Location	Outside Location	Wet Location	Horizontal	Along Grain	Inside Location	Outside Location	Wet Location	Inside Location	Outside Location	Wet Location			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Quercus lineata	Oak	W. Bengal	874	126·3	15·2	12·7	10·1	1·21	1·73	9·6	8·6	7·0	5·3	4·1	3·4	II	c	A
Quercus semecarpifolia	—	Punjab	834	115·8	15·8	13·1	10·5	1·27	1·81	8·3	7·3	6·0	3·8	2·9	2·4	—	—	A
*Shorea robusta**	Sal	M. P.	805	126·7	16·9	14·0	11·2	0·94	1·34	10·6	9·4	7·7	4·6	3·5	2·9	I	e	A
Soymida febrifuga	Rohini	Madras	1 116	122·2	21·5	17·9	14·4	1·62	2·32	15·0	13·3	10·9	12·9	10·0	8·2	I	—	A
Shorea talura	—	Maharashtra	721	122·0	16·8	14·0	11·2	1·10	1·56	12·6	11·2	9·2	6·8	5·3	4·3	—	—	—
Pterygota alata (Syn. *Sterculia alata*)	Narikel	Assam	593	109·5	13·4	11·8	8·9	0·84	1·20	8·2	7·3	6·0	2·7	2·1	1·7	III	—	C
Syzygium cumini	Jaman	Assam	841	105·5	14·8	12·4	9·9	1·11	1·58	9·0	8·0	6·5	6·9	5·4	4·4	II	e	A
Terminalia bellirica	Bahera	U. P.	729	101 9	13·6	11·3	9·0	0·96	1·37	8·4	7·5	6·1	3·7	2·8	2·3	III	b	B
Terminalia chebula	Myrobalan	—	918	123·7	17·1	14·2	11·4	1·12	1·60	1·17	10·4	8·5	6·7	5·2	4·3	II	c	A
Terminalia citrina	—	Assam	755	118·9	17·1	14·3	11·4	1·11	1·59	10·8	9·6	7·9	5·0	3·9	3 2	—	—	—
Terminalia manii	Black-chuglam	S. Andaman	822	126·6	16·8	14·0	11·2	1·12	1·60	10·3	9·2	7·5	5·1	4·0	3·2	II	a	B
Tectona grandis	Teak	U. P.	660	99·7	15·5	12·9	10·3	1·15	1·64	9·4	8·3	6·8	4·5	3·5	2·8	I	e	B
Terminalia paniculata	Kindal	Maharashtra	765	105·7	13·1	10·9	8·7	0·92	1·32	8·6	7·7	6·3	3·6	2·8	2·3	I	c	A
Alreminalia alata	Laurel, Sain	Madras	906	105·4	15·1	12·5	10·0	1·10	1·58	9·4	8·4	6·8	6·2	4·8	4·0	I	b	A
Terminalia bilata	White-chuglam	S. Andaman	690	123·8	15·5	13·0	10·4	0·87	1·24	9·8	8·7	7·1	3·6	2·8	2·3	III	e	B
Thespesia populnea	Bhendi	Maharashtra	766	103·6	18·9	15·8	12·6	1·32	1·88	11·3	10·0	8·2	4·4	3·4	2·8	—	—	B
Xylia xylocarpa	Irul	Maharashtra	839	116·3	16·2	13·5	10·8	1·28	1·83	10·9	9·7	7·9	7·8	6·0	4·9	I	e	A
Zanthoxylum budranga	Mullilam	W. Bengal	587	106·5	14·7	12·2	9·8	0·87	1·24	9·5	8·4	6·9	3·4	2·6	2·1	I	e	B
Adina oligocephala	—	Arunachal	715	111·7	15·2	12·7	10·1	1·20	1·70	10·3	9·2	7·5	4·0	3·1	2·4	—	—	—
Castanopsis indica	Chestnut	Meghalaya	688	125·4	14·8	12·3	9·9	0·98	1·40	9·8	8·7	7·1	3·4	2·7	2·2	—	—	B
Eucalyptus citriodara	Eucalyptus	Nilgiri	831	121·2	17·3	14·4	11 5	1·38	1·96	11·0	9·8	8·0	4·2	3·3	2·7	—	—	—
Eucalyptus citriodata	Eucalyptus	Ooty	725	93·5	15·4	12·9	10·3	0·99	1·41	8·6	7·6	6·3	3·0	2·4	2·0	—	—	—
Eucalytus tereticornis	Eucalyptus	Madras	777	110·5	16·7	13·9	11·1	0·96	1·38	9·7	8·6	7·1	3·4	2·6	2·2	—	—	—
GROUP C																		
Tbizia procera	White siris	U. P.	643	90·2	13·4	11·2	8·9	0·98	1·40	8·5	7·6	6·2	4·3	3·3	2·7	I	c	B
Artocarpus lakoocha	Lakooch	U. P.	647	61·4	10·0	8·3	6·7	0·98	1·41	5·3	4·7	3·8	2·8	2·2	1·8	I	—	B
Artocarpus hetarophyllus (Syn. *A. Integrifolia*)	Jack, kathal	Madras	617	94·6	13·9	11·6	9·2	1·04	1·48	9·3	8 3	6·8	4·5	3·5	2·9	I	—	B
Aphanamixis polystachya (Syn. *Amoora rohituka*)	Pitraj	W. Bengal	668	89·8	12·3	10·2	8·2	1·08	1·54	8·0	7·1	5·8	4·0	3·1	2·6	I	—	B
*Adina cordifolia**	Haldu	U. P.	663	85·4	13·3	11·1	8·9	0·96	1·36	8·7	7·7	6·3	4·4	3·4	2·8	III	a	B
Anthocephyalus chinensis (Syn. *A. Cadamba*)	Kadam	—	485	18·8	9·7	8·1	6·4	0·69	0·98	5·9	5·3	4·3	1·9	1·5	1·2	III	a	—
Artocarpus chaplasha	Chaplash	Assam	515	91·1	13·2	11·0	8·8	0·86	1·22	8·5	7·5	6·2	3·6	2·8	2·3	II	d	B
Acacia leucophloea	Hiwar	M. P.	737	78·5	13·4	11·2	9·0	1·03	1·47	7·5	6·7	5·4	4·5	3·5	2·8	—	—	A
Acacia melanoxylone	Black wood	Madras	630	94·5	13·0	10 8	8·7	1·05	1·50	7·6	6·8	5·5	3·2	2·5	2·0	—	—	—
Acacia mearnsii (Syn. *A. mollissima*)	Black wattle	Madras	669	61·0	10·4	8·6	6 9	0·83	1·18	6 0	5·4	4·4	2·3	1·8	1·5	—	—	—
Acer spp.	Maple	Punjab, U. P	551	73·5	9·9	8·2	6·5	0·88	1·25	5·5	4 9	4·0	2·1	1·7	1·4	III	—	B
Aegle marmelos (Syn. *Intsia bijuga*)	Bael	U. P.	890	88·1	13·5	11·2	9·0	1·40	2·00	8·8	7 8	6·4	6·8	5·3	4·3	III	—	B
Afzelia bijuga	—	Andaman	705	91·6	13·2	11·0	8·8	1·08	1·54	7·9	7·1	5·8	4·0	3·1	2·6	—	—	—
Ailanthus grandis	Gokul	W. Bengal	404	79·4	8·3	6·9	5·5	0·58	0·82	5·3	4·7	3·9	1·1	0·9	0·7	III	—	C
Anogeissus pendula	Kardhai	U. P.	929	97·5	17·0	14·2	11·4	1·28	1·84	9·8	8·7	7·1	6·5	5·1	4·2	III	—	A

(*Continued*)

Table 1 (*Continued*)

Species		Locality From Where Tested	Average Unit Mass at 12 Percent Moisture Content	Modulus of Elasticity (All Grades and All Locations)	Permissible Stress in N/mm² for Grade 1											Preservative Characters		§Refractoriness to Air Seasoning
					Bending and Tension Along Grain, Extreme Fibre Stress			Shear All locations		Compression Parallel to Grain			Compression Perpendicular to Grain			†Durability Class	‡Treatability Grade	
Botanical Name	Trade Name				Inside Location	Outside Location	Wet Location	Horizontal	Along Grain	Inside Location	Outside Location	Wet Location	Inside Location	Outside Location	Wet Location			
			kg/m³	N/mm²														
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Areca nut	—	Kerala	833	94·8	15·2	12·7	10·2	1·22	1·59	10·8	9·6	7·8	7·3	5·7	4·7	—	—	—
Albizia lucida	—	Arunachal, A. P.	566	85·1	10·7	8·9	7·1	08·2	1·18	7·3	6·5	5·3	2·3	1·8	1·5	—	—	—
Azadirachta indica	Neem	U. P.	836	85·2	14·6	12·1	9·7	1·29	1·84	10·0	8·9	7·3	5·0	3·9	3·2	—	—	—
Boswellia serrata	Salai	Bihar	551	72·1	9·4	7·9	6·3	0·73	1·05	5·5	4·9	4·0	2·1	1·6	1·3	I	e	C
Bridelia retusa	Kassi	Bihar	584	94·2	11·6	9·7	7·7	0·88	1·26	7·1	6·3	5·1	4·0	3·1	2·6	I	e	B
Betula alnoides	Birch	W. Bengal	625	92·3	9·6	8·0	6·4	0·76	1·08	5·7	5·0	4·1	2·2	1·7	1·4	—	—	B
Bischofia javanica	Uriam Bishopwood	Madras	769	88·4	9·6	8·2	6·5	0·79	1·12	5·9	5·3	4·3	3·6	2·8	2·3	III	—	A
Bursera serrata (Syn. *Protium serratum*)	Muntenga	A. P.	756	11·7	15·5	13·3	10·5	0·90	1·30	10·1	9·0	7·4	5·3	4·1	3·4	II	c	—
Careya arborea	Kumbi	U. P.	889	83·7	13·1	10·9	8·8	1·03	1·48	7·7	6·8	5·6	5·3	4·1	3·4	I	—	A
Cedrus deodara	Deodar	H. P.	557	94·8	10·2	8·7	7·2	0·70	1·00	7·8	6·9	5·7	2·7	2·1	1·7	I	c	C
Cupressus torulosa	Cypress	U. P.	506	84·1	8·8	7·6	6·2	0·57	0·82	6·9	6·2	5·0	2·4	1·8	1·5	I	e	C
Castanopsis hystrix	Indian chestnut	W. Bengal	624	98·5	10·6	8·8	7·0	0·82	1·17	6·4	5·7	4·6	2·7	2·1	1·7	II	b	B
Chukrasia velutina (Syn. *C. Tabularis*)	Chickrassy	W. Bengal	666	83·5	11·8	9·8	7·9	1·05	1·50	7·1	6·3	5·2	3·9	3·1	2·5	II	c	B
Calophyllum wightianum	Poon	Maharashtra	689	86·8	13·5	11·2	9·0	0·95	1·36	8·7	7·8	6·4	4·0	3·1	2·5	III	e	B
Canarium strictum	White dhup	Assam	569	105·4	10·1	8·4	6·7	0·74	1·06	6·2	5·5	4·5	2·1	1·6	1·3	III	—	C
Chlorophora excelsa	—	Madras	471	65·7	10·2	8·5	6·8	0·49	0·70	6·4	5·6	4·6	2·0	1·6	1·3	—	—	—
Cocosnucifera	Coconut	Kerala	761	73·4	9·2	7·7	6·1	0·74	1·05	9·5	8·4	6·9	3·9	3·0	2·5	—	—	—
Dalbergia latifolia	Rosewood	M. P.	884	83·9	12·9	10·8	8·6	1·08	1·55	8·0	7·1	5·8	4·2	3·3	2·7	I	—	B
Dalbergia sissoo	Sissoo	Punjab	799	71·4	12·8	10·7	8·5	1·25	1·79	8·2	7·3	6·0	4·2	3·3	2·7	I	e	B
Dillenia indica	Dillenia	W. Bengal	647	86·1	12·1	10·0	8·0	0·83	1·18	7·3	6·5	5·3	2·7	2·1	1·7	III	a	B
Dillenia pentagyna	Dillenia	W. Bengal	622	75·6	11·8	9·9	7·9	0·94	1·34	7·1	6·3	5·2	3·5	2·7	2·2	III	d	B
Diospyros melanoxylon	Ebony	Maharashtra	818	76·9	10·9	9·1	7·3	0·85	1·22	7·0	6·2	5·1	3·3	2·6	2·1	II	—	A
Duabanga grandiflora (Syn. *D. Sonneratioides*)	Lampati	W. Bengal	485	83·8	9·8	8·2	6·5	0·60	0·85	6·4	5·7	4·7	1·8	1·4	1·1	III	e	C
Elaeocarpus tuberculatus	Rudrak	Madras	466	87·4	9·7	8·1	6·4	0·70	0·99	6·3	5·6	4·6	2·0	1·5	1·3	—	—	C
Eucalyptus hybrid	Mysore gum	Madras	753	60·0	10·2	8·5	6·8	0·85	1·20	7·3	6·5	5·3	4·0	3·1	2·5	—	—	—
Calstros rhomboidea (Syn. *Frenela rhomboidea*)	—	Madras	607	64·8	9·2	7·7	6·1	0·70	1·00	6·9	6·1	5·0	4·0	3·1	2·6	—	—	—
Garuga pinnata	Garuga	U. P.	571	75·8	11·7	9·7	7·8	1·01	1·45	7·2	6·4	5·3	3·4	2·6	2·1	I	e	B
Gmelina arborea	Gamari	U. P.	501	70·2	9·8	8·2	6·6	0·84	1·21	5·7	5·0	4·1	4·2	3·2	2·7	I	e	B
Gardenia latifolia	gardenia	M. P.	705	71·3	14·1	11·7	9·4	1·20	1·70	8·4	7·4	6·1	4·6	3·6	3·0	—	—	—
Hardwickia binata	Anjan	M. P.	852	66·4	14·1	11·8	9·4	1·29	1·84	9·0	8·0	6·5	7·4	5·6	4·7	I	e	—
Holoptelea integrifolia	Kanju	U. P.	592	74·6	12·0	10·0	8·0	0·89	1·28	6·7	6·0	4·9	2·8	2·2	1·8	III	b	B
Heterophragma roxburghii	Palang	M. P.	616	86·9	12·3	10·2	8·2	0·67	0·96	7·9	7·0	5·7	3·4	2·6	2·1	—	—	—
Juglans spp.	Walnut	U. P.	565	90·0	9·9	8·3	6·6	0·85	1·22	5·8	5·2	4·2	2·2	1·7	1·4	III	—	B
Lagerstroemia speciosa (Syn. *L. flosregikal*)	Jarul	N. Andaman	622	85·3	12·1	10·1	8·1	0·82	1·17	7·7	6·8	5·6	3·4	2·6	2·2	II	e	B

(*Continued*)

Table 1 (*continued*)

Species		Locality From Where Tested	Average Unit Mass at 12 Per-cent Moisture Content	Modulus of Elasticity (All Grades and All Locations)	Permissible Stress in N/mm² for Grade I										Preservative Characters		§Refractori-ness to Air Seasoning
					Bending and Tension Along Grain, Extreme Fibre Stress			Shear All Locations		Compression Parallel to Grain			Compression Perpendicular to Grain			†Durabi-lity Class	‡Treat-ability Grade	
Botanical Name	Trade Name		kg/m³	N/mm³	Inside Loca-tion	Outside Loca-tion	Wet Loca-tion	Horizon-tal	Along Grain	Inside Loca-tion	Outside Loca-tion	Wet Loca-tion	Inside Loca-tion	Outside Loca-tion	Wet Loca-tion			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Lannea grandis (Syn. *L. coromandelica*)	Jhingan	U. P.	557	56·3	8·5	7·1	5·7	0·64	0 91	4·9	4·4	3·6	2·2	1·7	1·4	III	e	B
Leucaena leucocephala	Subabul	U. P.	673	63·2	11·6	9·7	7·8	1·04	1·49	7·4	6·6	5·4	3·8	3·0	2·4			
Lophopatalum wightianum	Banati	Madras	460	73·3	8·5	7·5	5·6	0·53	0·83	5·3	4·7	3·8	1·8	1·4	1·1	III	—	C
Madhuca longifolia var. latifolia (Syn. *Bassia latifolia*)	Mahua	M. P.	936	88·2	13·0	10·8	8·7	1·01	1·44	7·5	6·7	5·5	6·3	4·9	4·0	I	e	A
Mangifera Indica	Mango, Aam	Orissa	661	91·2	12·2	10·2	8·2	0·96	1·37	7·3	6·5	5·3	3·1	2·4	2·0	III	a	C
Machilus macrantha	Machilus	Madras	521	76·3	10·2	8·5	6·8	0·71	1·02	6·3	5·6	4·6	2·4	1·9	1·5	III	e	B
Mallotus philippinensis	Raini	U. P.	662	75·1	10·8	9·0	7·2	0·96	1·36	6·0	5·4	4·4	2·9	2·3	1·8	III	—	B
Manglietia insignia	—	Assam	449	103·7	10·9	9·1	7·3	0·68	0·98	8·0	7·1	5·8	3·4	2·6	2·1	—	—	—
Michelia montana	Champ	W. Bengal	512	82·5	10·9	9·1	7·3	0·72	1·02	6·6	5 9	4·8	2·8	2·2	1·8	I	—	B
Mitragyna parvifolia (Syn. *Stephegyne parvifolia*)	Kaim	U. P.	651	78·2	12·6	10·5	8·4	1·04	1·49	7·9	7·0	5·7	3·7	2·9	2·4	III	b	B
Michelia excelsa	Champ	W. Bengal	513	101·2	9·8	8·2	6·5	0·72	1·03	6·1	5·5	4·5	1·6	1·3	1·0	II	e	B
Milliusa velutina	Domsal	U. P.	747	79·2	11·7	9·7	7·8	1·14	1·63	7·0	6·3	5·1	3·7	2·9	2·4	III	—	—
Morus alba	Mulberry	U. P.	743	82·0	11·8	9·8	7·9	1·00	1·43	6·6	5·8	4·8	3·8	2·9	2·4	III	—	B
Morus serrata	Mulberry	H. P.	657	70·3	10·2	8·5	6·8	0·91	1·30	5·6	5·0	4·1	2·6	2·0	1·6	III	—	B
Morus laevigata	Bola	Andaman	588	86·1	12·3	10·2	8·2	1·02	1·46	7·2	6·4	5·3	3·3	2·5	2·1	—	—	B
Ougeinia oojeinensis (Syn. *O. dalbergioides*)	Sandan	M. P.	784	85·4	13·3	11·1	8·9	1·21	1·72	8·5	7·5	6·2	5·1	3·9	3·2	I	—	B
Phoebe hainesiana	Bonsum	Assam	566	95·0	13·2	11·0	8·8	0·84	1·21	8·8	7·8	6·4	2·8	2 1	1·8	II	c	B
Pinus roxburghii (Syn. *P. longifolia*)	Chir	U. P.	525	98·2	8·5	7·3	6·0	0·62	0·88	6·0	5·3	4·4	2·0	1·5	1·3	III	b	C
Pinus wallichiana	Kail		515	68·0	6·6	5·6	5·0	0·60	0·80	5·2	4·6	3·8	1·7	1·3	1·0	II	c	C
Phoebe goalparensis	Bonsum	Assam	511	76·5	9·7	8·1	6·5	0·70	1·01	6·6	5·9	4·8	2·2	1·7	1·4	II	c	B
Parrotiopsis jacquemontiana	Rohu Parrotia	H. P.	761	57·7	12·5	10·4	8·3	1·15	1·65	6·8	6·1	5·0	4·0	3·1	2·5	III	—	B
Pinus kesia (Syn. *Pinus insularis*)	Khasi pine	North East	513	73·8	8·9	7·4	5·9	0·57	0·74	5·8	5·2	4·3	1·5	1·2	1·0	—	—	B
Pistacia integerrima	Kikar singhi	J. & K.	881	73·2	13·1	10·9	8·7	1·20	1·71	8·0	7·1	5·8	4·3	3·4	2·8	—	—	—
Podocarpus nerrifolius	Thitmin	S. Andaman	533	94·1	12·5	10·4	8·3	06·1	0·86	8·0	7·1	5·8	2·6	2·0	1·6	II	—	—
Polyalthia fragranas	Debdaru (Nedunar)	Maharashtra	752	91·5	11·9	9·9	7·9	0·83	1·19	6·7	6·0	4·9	3·0	2·3	1·9	III	—	B
Polyalthia cerasoides		M. P.	700	92·9	13·2	11·0	8·8	0·97	1·39	7·1	6·3	5·2	3·2	2·5	2·0	—	—	—
Prunus napaulensis	Arupati	W. Bengal	548	94·1	104·4	8·7	69·6	0·86	1·23	6 7	6·0	4·9	2·4	1·9	1·6	—	—	—
Pterospermum acerifolium	Hattipaila	W. Bengal	607	95·5	13·5	11·3	9·0	0·85	1·22	8·7	7·7	6·3	3·2	2·5	2·0	III	c	B
Quercus spp.	Oak	North East	657	116·5	11·4	9·5	7·6	0·84	1·19	6·7	5·9	4·8	2·0	1·6	1·3	II	c	B
Raderomachera xylocarpa (Syn. Sterosperam xylocarpum)	Vedankonnai	Madras	696	85·2	13·2	11·0	8·8	1·06	1·52	9·0	8·0	6·6	4·3	3·3	2·7	II	—	—

(*Continued*)

Table 1 (*concluded*)

Species		Locality From Where Tested	Average Unit Mass at 12 Percent Moisture Content	Modulus of Elasticity (All Grades and All Locations)	Permissible Stress in N/mm² for Grade 1										Preservative Characters		§Refractoriness to Air Seasoning
					Bending and Tension Along Grain, Extreme Fibre Stress			Shear All locations		Compression Parallel to Grain			Compression Perpendicular to Grain			†Durability Class	‡Treatability Grade	
Botanical Name	Trade Name				Inside Location	Outside Location	Wet Location	Horizontal	Along Grain	Inside Location	Outside Location	Wet Location	Inside Location	Outside Location	Wet Location			
			kg/m³	N/mm²														
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Schleichera oleosa (Syn. *S. trijuga*)	Kusum	Bihar	1 032	121·2	15·5	13·0	10·4	1·47	2·11	10·9	9·7	7·9	6·1	4·2	3·9	II	a	A
Schima wallichii	Chilauni	W. Bengal	693	95·7	11·1	9·3	7·4	0·89	1·28	6·6	5·9	4·8	2·3	1·8	1·4	III	d	B
Shorea assamica	Makai	Assam	548	92·7	11·1	9·2	7·4	0·91	1·29	7·1	6·3	5·2	2·9	2·2	1·8	III	c	B
Sonneratia apetala	Keora	W. Bengal	617	86·3	12·8	10·7	8·5	0·92	1·32	7·4	6·6	5·4	4·8	3·7	3·0	II	—	B
Stereospermum suaveolans	Padri	U. P.	721	88·6	13·3	11·1	8·9	0·90	1·29	7·3	7·0	5·7	3·5	2·7	2·2	III	—	B
Tectona grandis	Teak	M. P.	617	84·9	12·8	10·7	8·5	0·84	1·30	7·9	7·0	5·7	4·0	3·1	2·6	I	e	B
Terminalia arjuna	Arjun	Bihar	794	77·1	12·2	10·2	8·2	1·12	1·60	7·4	6·6	5·4	5·2	4·1	3·3	II	b	B
Terminalia myriocarpa	Hollock	Assam	615	96·2	11·9	9·9	8·0	0·85	1·21	7·6	6·7	5·5	2·9	2·2	1·8	III	a	B
Terminalia procera	White bombwae	N. Andaman	626	89·9	11·8	9·8	7·9	0·89	1·27	7·2	6·4	5·3	3·0	2·3	1·9	III	b	B
Taxus buccata	Yew	W. Bengal	705	77·9	14·3	11·9	9·5	1·22	1·74	8·7	7·8	6·4	4·7	3·7	3·0	—	—	—
Tamarindus indica	Imli	Madras	913	56·3	11·4	9·5	7·6	1·22	1·71	7·0	6·2	5·1	5·3	4·1	3·4	—	—	B
Toona ciliata	Toon	U. P.	487	64·0	8·7	7·3	5·8	0 70	1·00	5·4	4·8	3·9	2·4	1·8	1·5	II	c	B
Vateria indica	Vellapine	Madras	535	109·5	11·5	9·6	7·6	0·73	1·05	7·5	6·7	5·5	2·3	1·8	1·4	III	e	C
Aesculas indica	Horse chestnut	U. P.	484	75·5	8·5	7·1	5·7	0·78	1·11	4·8	4·2	3·5	1·8	1·4	1·1	—	—	B
Borassus flabelifer	Tad (Palmyra)	A. P.	838	87·9	10·5	8·8	7·0	0·67	0·96	10·0	8·8	7·2	4·7	3·6	2·7	—	—	—
Eucelyptus camaldulensis	Eucalyptus	Karnataka	804	95·3	12·8	10·6	8·5	0·78	1·11	7·2	6·4	5·2	3·5	2·7	2·2	—	—	A
Eucalyptus camaldulenis	Eucalyptus	U. P.	781	70·3	12·4	10·4	8·3	1·12	1·60	7·9	7·0	5·7	3·5	2·8	2·3	—	—	A
Eucalyptus pisularia	Eucalyptus	T. N.	713	92·2	14·8	12·3	11·1	0·99	1·41	8·5	7·6	6·2	2·8	2·2	1·8	—	—	A
Eucalyptus propingus	Eucalyptus	T. N.	584	79·3	12·8	10·7	8·5	0·80	1·15	8·0	5·4	4·4	2·5	1·9	1·6	—	—	A
Eucalyptus saligna	Eucalyptus	U. P.	819	82·4	11·5	9·6	7·6	1·46	2·08	8·2	7·3	6·0	6·2	4·8	4·0	—	—	A

*Species thus marked and tested from other localities show higher strength to enable their categorization in higher group.

For Example

i) Sal tested from West Bengal, Bihar, U. P. and Assam can be classified as Group 'A' species;

ii) Haldu tested from Bihar can be classified as Group 'B' species;

iii) Morus laevigate (Bole) of Assam can be classified in Group 'B' species.

†Classification for preservation based on durability tests, etc.

Class

I—Average life more than 120 months;

II—Average life 60 months and above but less than 120 months; and

III—Average life less than 60 months.

‡*Treatability Grades*

a— Heartwood easily treatable;
b— Heartwood treatable, but complete penetration not always obtained; in case where the least dimension is more than 60 mm;
c— Heartwood only partially treatable;
d— Heartwood refractory to treatment; and
e— Heartwood very refractory to treatment, penetration of preservative being practically nil even from the ends.

¶Data based on strength properties at three years of age of tree.

§Classifications based on seasoning behaviour of timber and refractoriness w.r.t. cracking, spliting and drying rate:

A = Highly refractory (slow and difficulty to season free from surface and end cracking);

B = Moderately refractory (may be seasoned free from surface and end cracking within reasonably short periods, given a little protection against rapid drying conditions): and

C = Non-refractory may be rapidly seasoned free from surface and end-cracking even in the open air and sun. If not rapidly dried, they dovelop blue stain and mould on the surface.

Table 2 Recommended Moisture Content Values (Percent)

(*Clause* 5.3)

Sl No.	Use	Zones (*see* Note)			
		I	II	III	IV
1.	Structural elements	12	14	17	20
2.	Joinery (doors and windows)	10	12	14	16

NOTE — The country has been broadly divided into the following four zones based on the humidity variations:

Zone I Average annual relative humidity less than 40 percent,

Zone II Average annual relative humidity 40 to 50 percent,

Zone III Average annual relative humidity 50 to 67 percent, and

Zone IV Average annual relative humidity more than 67 percent.

5.4 Requirements of Structural Timber

The various other requirements of structural timber for use in building shall conform to IS 3629 : 1986.

5.5 Sawn Timber

The cut sizes of timber stock for structural purposes shall be in accordance with IS 4891 : 1988.

5.6 Grading of Structural Timber

5.6.1 The cut sizes of structural timber shall be graded, after seasoning, in accordance with IS 1331 : 1975 into the following three grades:

a) Select grade,

b) Grade I, and

c) Grade II.

5.6.2 The prohibited defects given in **5.6.2.1** and permissible defects given in **5.6.2.2** and **5.6.2.3** shall apply to structural timber in accordance with IS 3629 : 1986.

5.6.2.1 *Prohibited defects*

All grades of timber with the following defects shall not be used for structural purposes:

a) Loose grain, splits, compression wood in coniferous species, heartwood rot, sap rot, and crookedness; and

b) Worm holes made by powder post beetles and pitch pockets.

5.6.2.2 *Permissible defects*

The following defects are permitted for all grades of timber:

a) Wanes, provided (i) they are not combined with knots and reduction in strength due to this is not more than reduction with the maximum allowable knots, and (ii) there is no objection to its use as bearing area or with respect to nailing edge distance and the general appearance.

b) Worm holes other than those due to powder post beetles; reduction in strength to be evaluated in the same way as for knots depending upon location and grouping of such holes.

c) All other defects unlikely to affect any of the mechanical strength properties.

5.6.2.3 Besides the permissible defects under **5.6.2.2**, for knots, and checks and shakes provisions given in **8.2.2** and **8.2.3** of IS 3629 : 1986 shall apply.

5.6.2.4 *Location of defect*

The influence of defects in timber is different for different locations in a structural element. Therefore, these should be so placed during construction in accordance with good practices that they do not have any adverse effect on the member.

5.7 Suitability in Respect of Durability and Treatability

5.7.1 There are two choices for normal good structures as given below and listed in Table 1 (*see also Table* 1 *of* IS 3629 : 1986).

5.7.1.1 *First choice*

The species of timber shall be any one of the following categories:

a) Untreated heartwood of high durability. Heartwood if containing more than 15 percent sap wood, may need chemical treatment for protection;

b) Treated heartwood of moderate and low durability and class 'a' and class 'b' treatability;

c) Heartwood of moderate durability and class 'c' treatability after pressure impregnation; and

d) Sapwood of all classes of durability after thorough treatment with preservatives.

5.7.1.2 *Second choice*

The species of timber shall be of heartwood of moderate durability and class 'd' treatability.

5.7.2 Choice for load-bearing temporary structures or semi-structurals at construction site—

a) Heartwood of low durability and class 'e' treatability; or

b) The species whose durability and/or treatability is yet to be established, as listed in Table 1.

5.7.3 *Storing of Timber*

This shall be in accordance with IS 3629 : 1986.

6 PERMISSIBLE STRESSES

6.1 Fundamental stress values of different species of timber are determined on small specimen in accordance with standard practice laid in IS 1708 (Parts 1 to 18) : 1986. In these values are then applied appropriate reduction factors given in the relevant table of IS 3629 : 1986 to obtain the permissible stresses.

6.2 The permissible stresses for Groups A, B and C for different locations of use and applicable to Grade I of structural timbers shall be as given in Table 1; and the corresponding minimum permissible stress limits shall be as given in Table 3, provided that the following conditions are met:

a) The timber should be of high or moderate durability and be given suitable treatment where necessary,

b) Timber of low durability shall be used after proper preservative treatment in accordance with IS 401 : 1982, and

c) The loads should be of continuous and permanent type.

6.3 For permissible stresses (excepting E) of other grades of timber, values given in Table 1 and Table 3 shall be multiplied by the following factors, provided that the conditions laid down in **6.2** are satisfied:

a) For Select Grade Timber 1·16

b) For Grade II Timber 0·84

6.3.1 When low durability timbers are to be used on outside location, the permissible stresses for all grades of timber, arrived at by **6.2** and **6.3** shall be multiplied by 0·80.

6.4 Modification Factors for Permissible Stresses

6.4.1 *Due to Change in Slope of Grain*

When the timber has not been graded and has major defects such as slope of the grain, knots and checks or shakes (but not beyond permissible values), the permissible stresses given in Table 1 shall be multiplied by the modification factor K_1 for different slopes of grain as given in Table 4.

6.4.2 *Due to Duration of the Load*

For different durations of design load, the permissible stresses given in Table 1 shall be multiplied by the modification factor K_2 given in Table 5.

6.4.2.1 The factor K_2 is applicable to modulus of elasticity when used to design timber columns, otherwise they do not apply thereto.

6.4.2.2 If there are several durations of loads (in addition to continuous) to be considered, the modification factor shall be based on the shortest duration load in the combination, that is, the one yielding the largest increase in the permissible stresses, provided the designed section is found adequate for a combination of other longer duration loads.

[*Explanation* : In any structural timber design for dead loads, snow loads and wind or earthquake forces, members may be designed on the basis of total of stresses due to dead, snow and wind loads using $K_2 = 1{\cdot}33$, factor for the permissible stress (of Table 1) to accomodate the wind load, that is, the shortest of duration and giving the largest increase in the permissible

Table 3 Minimum Permissible Stress Limits (N/mm²) in Three Groups of Structural Timbers (For Grade I Material)

(*Clauses* 6.2 *and* 6.3)

Sl No.	Strength Character	Location of Use	Group A	Group B	Group C
i)	Bending and tension along grain	Inside [2]	18·0	12·0	8·5
ii)	Shear [1]				
	Horizontal	All locations	1·05	0·64	0·49
	Along grain	All locations	1·5	0·91	0·70
iii)	Compression parallel to grain	Inside [2]	11·7	7·8	4·9
iv)	Compression perpendicular to grain	Inside [2]	4·0	2·5	1·1
v)	Modulus of elasticity ($\times 10^3$ N/mm²)	All locations and grade	12·6	9·8	5·6

1) The values of horizontal shear to be used only for beams. In all other cases shear along grain to be used.

2) For working stresses for other locations of use, that is, outside and wet, generally factors of 5/6 and 2/3 are applied.

stresses. The section thus found is checked to meet the requirements based on dead loads alone with modification $K_2 = 1{\cdot}00$.]

Table 4 Modification Factor K_1 to Allow for Change in Slope of Grain

(*Clause* 6.4.1)

Slope	K_1	
	Strength of Beams, Joists and Ties	Strength of Posts or Columns
(1)	(2)	(3)
1 in 10	0·80	0·74
1 in 12	0·90	0·82
1 in 14	0·98	0·87
1 in 15 and flatter	1·00	1·00

Table 5 Modification Factor K_2 for Change in Duration of Loading

(*Clause* 6.4.2)

Sl No.	Duration of Loading	Modification Factor, K_2
(1)	(2)	(3)
i)	Continuous (Normal)	1·00
ii)	Two months	1·15
iii)	Seven days	1·25
iv)	Wind and earthquake	1·33
v)	Instantaneous or impact	2·00

6.4.2.3 Modification factor K_2 shall also be applied to allowable loads for mechanical fasteners in design of joints, when the wood and not the strength of metal determines the load capacity.

7 DESIGN CONSIDERATIONS

7.1 All structural members, assemblies or framework in a building, in combination with the floors, walls and other structural parts of the building shall be capable of sustaining, with due stability and stiffness the whole dead and imposed loadings as specified in appropriate codes [IS 875 (Parts 1 to 5) : 1987], without exceeding the limits of relevant stresses specified in this standard.

7.2 The worst combination and location of loads shall be considered for designs. Wind and seismic forces shall not be considered to act simultaneously.

7.3 The design requirements may be satisfied either by calculation using laws of mechanics or by prototype testing.

7.4 Net Section

7.4.1 The net section shall be obtained by deducting from the gross sectional area of timber the projected area of all material removed by boring, grooving or other means at critical plane. In case of nailing, the area of the prebored hole shall not be taken into account for this purpose.

7.4.2 The net section used in calculating load-carrying capacity of a member shall be the least net section determined as above by passing a plane or a series of connected planes transversely through the members.

7.4.3 Notches shall in no case, remove more than one quarter of the section.

7.4.4 In the design of an intermediate or a long column, gross section shall be used in calculating load-carrying capacity of the column.

7.5 Flexural Member

7.5.1 Such structural members shall be investigated for the following:

a) Bending strength,

b) Maximum horizontal shear,

c) Stress at the bearings, and

d) Deflection.

7.5.2 *Effective Span*

The effective span of beams and other flexural members shall be taken as the distance from of supports plus one-half of the required length of bearing at each end except that for continuous beams and joists the span may be measured from centre of bearing at those supports over which the beam is continuous.

7.5.3 Usual formula for flexural strength shall apply:

$$f_{ab} = \frac{M}{Z} \leqslant f_b$$

7.5.4 *Form Factors for Flexural Members*

The following form factors shall be applied to the bending stress:

a) *Rectangular section* — For rectangular sections, for different depths of beams, the form factor K_3 shall be taken as:

$$K_3 = 0{\cdot}81 \frac{D^2 + 89\,400}{D^2 + 55\,000}$$

NOTE — Form factor (K_3) shall not be applied for beams having depth less than or equal to 300 mm.

b) *Box beams and I-beams* — For box beams and I-beams the form factor K_4 shall be obtained by using the formula:

$$K_4 = 0{\cdot}8 + 0{\cdot}8\,y \left(\frac{D^2 + 89\,400 - 1}{D^2 + 55\,000} \right)$$

where

$$y = p_1^2 (6 - 8\,p_1 + 3\,p_1^2) (1 - q_1) + q_1$$

c) *Solid circular cross-sections* — For solid circular cross-sections, the form factor K_5 shall be taken as 1·18.

d) *Square cross-section* — For square cross-sections, where the load is in the direction of diagonal, the form factor K_6 shall be taken as 1·414.

7.5.5 *Width*

The minimum width of the beam or any flexural member shall not be less than 50 mm or 1/50 of the span, whichever is greater.

7.5.6 *Depth*

The depth of beam or any flexural member shall not be taken more than three times of its width without lateral stiffening.

7.5.6.1 *Stiffening*

All flexural members having a depth exceeding three times its width and or a span exceeding fifty times its width or both shall be laterally restrained from twisting or buckling and the distance between such restraints shall not exceed 50 times its width.

7.5.7 *Shear*

7.5.7.1 The following formulae shall apply:

a) The maximum horizontal shear, when the load on a beam moves from the support towards the centre of the span, and the load is at a distance of three to four times the depth of the beam from the support, shall be calculated from the following general formula:

$$H = \frac{VQ}{Ib}$$

b) For rectangular beam:

$$Q = \frac{1}{2} b \times D \times \frac{D}{4} = \frac{1}{8} b D^2$$

and $I_c = \frac{1}{12} b D^3$

That is, $H = \frac{VQ}{Ib} = \frac{3V}{2bD}$

c) Notched beams, with tension notch at the supports:

$$H = \frac{3 VD}{2 bD_1^2}$$

d) Notched at upper (compression) face, where $e \geq D$:

$$H = \frac{3V}{2 bD_1}$$

e) Notched at upper (compression) face, where $e < D$

$$H = \frac{3V}{2b\left[D - \left(\frac{D_1}{D}\right) e\right]}$$

7.5.7.2 For concentrated loads, $V = \frac{10C\,(l-x)\,(x/D)^2}{9l\,[2 + (x/D)^2]}$

and for uniformly distributed loads,

$$V = \frac{W}{2}\left(1 - \frac{2D}{l}\right)$$

After arriving at the value of V, its value will be substituted in the formula:

$$H = \frac{VQ}{I b}$$

H should be within the allowable safe permissible stress in horizontal shear recommended for the species.

7.5.7.3 In determining the vertical reaction V, the following deductions in loads may be made:

a) Consideration shall be given to the possible distribution of load to adjacent parallel beams, if any;

b) All uniformly distributed loads within a distance equal to the depth of the beam from the edge of the nearest support may be neglected except in case of beam hanging downwards from a particular support; and

c) All concentrated loads in the vicinity of the supports may be reduced by the reduction factor applicable according to Table 6.

Table 6 Reduction Factor for Concentrated Loads in the Vicinity of Support

Distance of Load from the Nearest Support	1·5 D or Less	2D	2·5D	3D or More
Reduction Factor	0·60	0·40	0·20	No reduction

NOTE — For intermediate distances, the reduction factor may be obtained by linear interpolation.

7.5.7.4 Unless the local stress is calculated and found to be within the permissible stress, flexural member shall not be cut, notched or bored except as follows:

a) Notches may be cut in the top or bottom neither deeper than one fifth of the depth of the beam nor farther from the edge of the support than one-sixth of the span;

b) Holes not larger in diameter than one-quarter of the depth may be bored in the middle third of the depth and length; and

c) If holes or notches occur at a distance greater than three times the depth of the member from the edge of the nearest support, the net remaining depth shall be used in determining the bending strength.

7.5.8 *Bearing*

7.5.8.1 The ends of flexural members shall be supported in recesses which provide adequate ventilation to prevent dry rot and shall not be enclosed. Flexural members except roof timbers which are supported directly on masonry or concrete shall have a length of bearing of not less than 75 mm. Members supported on corbels, offsets and roof timbers on a wall shall bear immediately on and be fixed to wall-plate not less than 75 mm × 40 mm.

7.5.8.2 Timber joists or floor planks shall not be supported on the top flange of steel beams unless the bearing stress, calculated on the net bearing as shaped to fit the beam, is less than the permissible compressive stress perpendicular to the grain.

7.5.8.3 *Bearing stress*

7.5.8.3.1 *Length and position of bearing*

a) At any bearing on the side grain of timber, the permissible stress in compression perpendicular to the grain, f_{cn} is dependent on the length and position of the bearing;

b) The permissible stresses given in Table 1 for compression perpendicular to the grain are also the permissible stresses for any length at the ends of members and for bearing 150 mm or more in length at any other position;

c) For bearings less than 150 mm in length and located 75 mm or more from the end of a member the permissible stress perpendicular to the grain may be multiplied by the modification factor K_7 given in Table 7;

d) No allowance need be made for the difference in intensity of the bearing stress due to bending of a beam;

e) The bearing area should be calculated as the net area after allowance for the amount of wane as permitted in IS 1331 : 1975;

f) For bearing stress under a washer or a small plate, the same coefficient recommended in Table 7 may be taken for a bearing with a length equal to the diameter of the washer or the width of the small plate; and

g) When the direction of stress is at an angle to the direction of the grain in any structural member, then the permissible bearing stress in that member shall be calculated by the following formula:

$$f_\theta = \frac{f_{cp} \times f_{cn}}{f_{cp} \sin^2 \theta + f_{cn} \cos^2 \theta}$$

Table 7 Modification Factor K_7 for Bearing Stresses

[*Clause* 7.5.8.3.1, (c) *and* (f)]

Length of Bearing in mm	15	25	40	50	75	100	150 or More
Modification factor, K_7	1·67	1·40	1·25	1·20	1·13	1·10	1·00

7.5.9 *Deflection*

7.5.9.1 The deflection in the case of all flexural members supporting brittle materials like gypsum ceilings, slates, tiles and asbestos sheets shall not exceed 1/360 of the span. The deflection in the case of other flexural members shall not exceed 1/240 of the span, and 1/150 of the freely hanging length in the case of cantilevers.

7.5.9.2 Usual formula for deflection shall apply:

$$\delta = \frac{KWL^3}{EI}$$ (ignoring deflection due to shear strain)

K-values $= \frac{1}{3}$ for cantilevers with load at free end,

$\frac{1}{8}$ for cantilevers with uniformly distributed load,

$\frac{1}{48}$ for beams supported at both ends with point load at centre, and

$\frac{5}{384}$ for beams supported at both ends with uniformly distributed load.

7.5.9.3 In order to allow the effect of long duration loading on E, for checking deflection in case of beams and joists the effective loads shall be twice the dead load if the timber is initially dry.

7.5.9.4 Self weight of beam shall be considered in design.

7.6 Columns

7.6.1 *Solid Columns*

Solid columns shall be classified into short, intermediate and long columns depending upon their slenderness ratio (S/d) as follows:

a) Short columns — where S/d does not exceed 11,

b) Intermediate columns — where S/d is between 11 and K_8, and

c) Long columns — where S/d is greater than K_8.

7.6.1.1 For short columns, the permissible compressive stress shall be calculated as follows:

$$f_c = f_{cp}$$

7.6.1.2 For intermediate columns the permissible compressive stress is calculated by using the following formula:

$$f_c = f_{cp}\left[1 - \frac{1}{3}\left(\frac{S}{K_8 d}\right)^4\right]$$

7.6.1.3 For long columns, the permissible compressive stress shall be calculated by using the following formula:

$$f_c = \frac{0{\cdot}329\,E}{(S/d)^2}$$

7.6.1.4 In case of solid columns of timber, S/d ratio shall not exceed 50.

7.6.1.5 The formulae given are for columns with pin end conditions and length shall be suitably modified with other end conditions.

7.6.1.6 The permissible load on a column of circular cross-section shall not exceed that permitted for a square column of an equivalent cross-sectional area.

7.6.1.7 For determining S/d ratio of a tapered column, its least dimension shall be taken as the sum of the corresponding least dimensions at the small end of the column and one-third of the difference between this least dimension at the small end and the corresponding least dimension at the large end, but in no case shall the least dimension for the column be taken as more than one and a half times the least dimension at the small end. The induced stress at the small end of the tapered column shall not exceed the permissible compressive stress in the direction of grain.

7.6.2 *Box and Built-up Columns*

7.6.2.1 Box columns shall be classified into short, intermediate and long columns as follows:

a) Short columns — where $\frac{S}{\sqrt{d_1^2 + d_2^2}}$ is less than 8,

b) Intermediate columns — where $\frac{S}{\sqrt{d_1^2 + d_2^2}}$ is between 8 and K_9, and

c) Long columns — where $\frac{S}{\sqrt{d_1^2 + d_2^2}}$ is greater than K_9.

7.6.2.2 For short columns, the permissible compressive stress shall be calculated as follows:

$$f_c = q f_{cp}$$

7.6.2.3 For intermediate columns, the permissible compressive stress shall be obtained using the following formula:

$$f_c = q f_{cp}\left[1 - \frac{1}{3}\left(\frac{S}{K_9\sqrt{d_1^2 + d_2^2}}\right)^4\right]$$

7.6.2.4 For long columns, the permissible compressive stress shall be calculated by using the formula:

$$f_c = \frac{0\ 329\ UE}{\left(\frac{S}{\sqrt{d_1^2 + d_2^2}}\right)^2}$$

7.6.2.5 The following values of U and q depending upon plank thickness (t) in **7.6.2.3** and **7.6.2.4** shall be used:

t	U	q
mm		
25	0·80	1·00
50	0·60	1·00

7.6.3 *Spaced Columns*

The formulae for solid columns as specified in **7.6.1** are applicable to spaced columns with a restraint factor of 2·5 or 3, depending upon distance of end connectors in the column.

NOTE — A restrained factor of 2·5 for location of centroid group of fasteners at $S/20$ from end and 3 for location at $S/10$ to $S/20$ from end shall be taken.

7.6.3.1 For intermediate spaced column the permissible compressive stress shall be:

$$f_c = f_{cp}\left[1 - \frac{1}{3}\left(\frac{S}{K_{10}d}\right)^4\right]$$

7.6.3.2 For long spaced columns the formula shall be:

$$f_c = \frac{0{\cdot}329\,E \times 2{\cdot}5}{(S/d)^2}$$

7.6.3.3 For individual member of spaced column S/d ratio shall not exceed 80.

7.6.4 Compression members shall not be notched. When it is necessary to pass services through such a member, this shall be effected by means of a bored hole provided that the local stress is calculated and found to be within the permissible stress specified. The distance from the edge of the hole to the edge of the member shall not be less than one-quarter of width of the face.

7.7 Structural Members Subject to Bending and Axial Stresses

7.7.1 Structural members subjected both to bending and axial compression shall be designed to comply with the following formula:

$$\frac{f_{ac}}{f_c} + \frac{f_{ab}}{f_b} \text{ is not greater than 1.}$$

7.7.2 Structural members subjected both to bending and axial tension shall be designed to comply with the following formula:

$$\frac{f_{at}}{f_t} + \frac{f_{ab}}{f_b} \text{ is not greater than 1.}$$

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*	*IS No.*	*Title*
287 : 1993	Recommendations for permissible moisture content for timber used for different purposes (*third revision*)	1331 : 1975	Specification for cut sizes of timber (*second revision*)
401 : 1982	Code of practice for preservation of timber (*third revision*)	1708 (Parts 1 to 18) : 1986	Methods of testing of small specimens of timber (*second revision*)
707 : 1976	Glossary of terms applicable to timber technology and utilization (*second revision*)	3629 : 1986	Specification for structural timber in buildings (*first revision*)
875 (Parts 1 to 5) : 1987	Code of practice for design loads (other than earthquake for buildings structures) (*second revision*)	4891 : 1988	Specification for preferred out sizes of structural timbers (*first revision*)

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This Indian Standard has been developed from Doc No. CED 13 (4788).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Printograph, New Delhi-5 (INDIA)