NEPAL NATIONAL BUILDING CODE

NBC 112 : 1994

TIMBER

His Majesty's Government of Nepal
Ministry of Physical Planning and Works
Department of Urban Development and Building Construction
Babar Mahal, Kathmandu, NEPAL
2060

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This publication represents a standard of good practice and therefore takes the form of recommendations. Compliance with it does not confer immunity from relevant legal requirements, including bylaws

श्री ५ को सरकार (मन्त्रिपरिषद्) को मिति २०६०।४।१२ को निर्णयानुसार स्वीकृत

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Preface

This Nepal Standard was prepared during 1993 as part of a project to prepare a draft National Building Code for Nepal.

In 1988 the Ministry of Housing and Physical Planning (MHPP), conscious of the growing needs of Nepal's urban and shelter sectors, requested technical assistance from the United Nations Development Programme and their executing agency, United Nations Centre for Human Settlements (UNCHS).

A programme of Policy and Technical Support was set up within the Ministry (UNDP Project NEP/88/054) and a number of activities have been undertaken within this framework.

The 1988 earthquake in Nepal, and the resulting deaths and damage to both housing and schools, again drew attention to the need for changes and improvement in current building construction and design methods.

Until now, Nepal has not had any regulations or documents of its own setting out either requirements or good practice for achieving satisfactory strength in buildings.

In late 1991 the MHPP and UNCHS requested proposals for the development of such regulations and documents from international organisations in response to terms of reference prepared by a panel of experts.

This document has been prepared by the subcontractor's team working within the Department of Building, the team including members of the Department and the MHPP. As part of the proposed management and implementation strategy, it has been prepared so as to conform with the general presentation requirements of the Nepal Bureau of Standards and Metrology.

The subproject has been undertaken under the aegis of an Advisory Panel to the MHPP.

The Advisory Panel consisted of :

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Mr. AR Pant, Under Secretary, MHPP	**Member**
Director General, Department of Mines & Geology (Mr. PL Shrestha)	**Member**
Director General, Nepal Bureau of Standards & Metrology (Mr. PB Manandhar)	**Member**
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Law Officer, MHPP (Mr. RB Dange)	**Member**
Representative, Society of Consulting Architectural & Engineering Firms (SCAEF)	**Member**

Representative, Society of Nepalese Architects (SONA) **Member**
Deputy Director General, Department of Building,
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SILT Consultants P. Ltd., Nepal
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0. Foreword

0.1 Design Aspect

This standard covers the general principle involved in the design of structural timber in buildings. It also covers the specifications for structural timber for use in buildings, including classification of such timber into suitable grades, as well as nail joint timber construction.

0.2 Related Codes

The requirement of this section shall be applied in conjunction with the Indian Standard **IS: 883-1970 Code of Practice for Design of Structural Timber in Building" (Third revision)** and **IS: 2366-1983 Code of Practice for Nail-Jointed Timber Construction (First Revision).**

1 Scope

1.1 Coverage

This standard provides a Code of Practice for the structural design of timber in buildings of Nepal.

1.2 Limitation

This section do not covers anti-termite timber, the use of plywood, or timber in pile foundation.

2 Interpretation

2.1 General

2.1.1 In this standard the word "shall" indicates a requirement that is to be adopted in order to comply with the Standard, while the word "should" indicates recommended practice.

2.1.2 Commentary clauses are prefaced by the letter C and the number of the appropriate clause subject to comment.

2.2 Terminology

The terminology given **IS : 883-1970** in clauses 2.0 to 2.19 will apply except as stated here below.

BOX COLUMN means a column made of four planks connected together so as to from a hollow core inside. The core is blocked by the solid pieces of timber at its ends and at least one intermediate point.

BUILD UP - SOLID COLUMN means those built up by spiking, nailing or bolting together planks or square section. The planks must be fastened together at intervals not greater than six times their thickness. The allowable stress on such a column shall be conservatively taken as 80 % of that of solid column.

CASE HARDENING means a condition of timber during seasoning in which the different layers of wood are under stress, by being under compression across the grain.

DURATION OF LOADING means the period during which a timber structure is stressed as consequence of the loads applied to it.

GREEN TIMBER means timber in which the moisture content is above its fibre-saturation point.

MOISTURE CONTENT means the weight of water contained in wood, expressed as a percentage of its oven -dry weight.

NOTE : *The moisture content of timber is generally determined by the oven-dry method.*

STRUCTURAL TIMBER means timber used or intended for use in buildings where strength is the primary consideration.

PERMISSIBLE STRESS means the basic stress as modified by factors reflecting the timber's defects, its location and the particulars of design.

SPACED COLUMN means two column sections in which the parts are adequately connected together by glue, bolts, screws or similar.

2.2.1 Definition of Defects in Timber

CHECK means a crack crossing radially the annual rings of the wood. This defect reduce the strength in shear directly in proportion to its size.

COMPRESSION WOOD means abnormal wood which is formed on the lower sides of branches and inclined stems of coniferous trees. It is darker and harder than normal wood but relatively low in strength for its weight. It can be usually identified by wide eccentric growth rings with an abnormally high proportion of latewood growth.

DEAD KNOT means a knot in which the layers of annual growth are not completely intergrown with those of the adjacent wood. It is surrounded by pitch or bark. The encasement may be partial or complete.

DECAY OR ROT means the disintegration of wood tissues caused byi (wood destroying) fungi or other micro-organisms.

DECAYED KNOT means a knot softer than the surrounding wood and containing decay.

DIAMETER OF KNOT means the maximum distance between the two points farthest apart on the periphery of a round knot, on the face on which it becomes visible. In the case of a spike or a splay knot, the maximum width of the knot visible on the face on which it appears shall be taken as its diameter.

DISCOLORATION means a change from the normal colour of the wood which does not impair the strength of the wood.

KNOT means a branch base or limb embedded in the tree or timbers by natural growth.

KNOT HOLE means a hole left as a result of the removal of a knot.

LIVE KNOT means a knot free from decay and other defects, in which the fibres are firmly intergrown with those of the surrounding wood.

LOOSE GRAIN (LOOSENED GRAIN) means a defect on a flat ,sawn surface caused by the separation or raising of wood fibres along the growth rings.

LOOSE KNOT means a knot that is not held firmly in place by growth or position, and that cannot be relied upon to remain in place.

MOULD means a soft vegetative growth that forms on wood in damp stagnant atmosphere. It is the least harmful type of fungus, usually confined to the surface of the wood.

PITCH POCKET means an accumulation of resin between growth rings of coniferous wood as seen on the cross section.

SAP STAIN means a discoloration of the sapwood mainly due to fungi.

SAP WOOD means the outer layer of a log which, in the growing tree contain living cells and food materials. The sapwood is usually lighter in colour and is readily attacked by insect and fungi.

SHAKE means a partial or complete separation between adjoining layers of tissues as seen in end surfaces.

SLOPE OF GRAIN means the inclination of the fibres to the longitudinal axis of the member.

SOUND KNOT means a tight knot free from decay, which is solid across its face, and at least as hard as the surrounding wood.

SPLIT means a crack extending from one face of a piece of wood to another and running along the grain of the piece.

TIGHT KNOT means a knot so held by growth or position as to remain firmly in position in the piece of wood.

WANE means the original rounded surface of a tree remaining on a piece of converted timber.

WARP means a deviation in sawn timber from a true plane surface ,or distortion due to stresses causing departure from a true plane.

WORM HOLES means cavities caused by worms.

2.3 Symbols

The symbol used are as per **IS: 883 - 1970** clause 3.0 unless inconsistent with the context. The following letters, symbols are used :

A	Area of cross section
b	Width of the beam, in mm.
D	Depth of beam, in mm.
D_1	Depth of beam, at the notch, in mm.
d	Dimension 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.
d_3	Diameter of bolt.
E	Modulus of elasticity in bending, in N/mm^2.
f_{ab}	Calculated bending stress in extreme fibre, in N/mm^2.
f_{ac}	Calculated average axial compressive stress, in N/mm^2.
f_{at}	Calculated axial tensile stress, in N/mm^2.
f_b	Permissible bending stress on the extreme fibre, in N/mm^2.
f_c	Permissible stress in axial compression, in N/mm^2.
f_{cn}	Permissible stress in compression normal (perpendicular) to grain, in N/mm^2.
f_{cp}	Permissible stress in compression parallel to grain, in N/mm^2.
f_{co}	Permissible compressive stress in the direction of the line of action of the load, in N/mm^2.
f_t	Permissible stress in tension parallel to grain, in N/mm^2.
H	Horizontal shear stress, in N/mm^2.
I	Moment of inertia of a section, in mm^4.
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	Form factors.

k_6|

k_7 Modification factor for bearing stress.

k_8 Constant equal to

$$0.702\frac{\sqrt{E}}{f_{cp}}$$

k_9 Constant equal to

$$\pi/2 \sqrt{\frac{UE}{5\,qf_{cp}}}$$

k_{10} Constant equal to

$$0.702 \sqrt{\frac{2.5E}{f_{cp}}}$$

L Span of beam or truss, in mm.

n Shank diameter of the nail.

p_1 Ratio of the thickness of the compression flange to the depth of the beam.

Q Static moment of area above or below the neutral axis about neutral axis, in mm^3.

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 Effective length of solid and box columns in mm, distance between points of lateral support of spaced column, in mm.

t Nominal thickness of planks used in forming box type column in mm.

U Constant for a particular thickness of the plank

V Vertical and reaction or shear at a section in kN.

Y A factor determining the value of form factor k_4

φ Angle of load to grain direction.

3 Materials

The provision in clauses 4.1 to 4.7.1.2 of IS : 883 – 1970 will be applicable in addition to the following clauses.

The general characteristics like durability and treatability of the species are also given in **Table 1**. Species of timber other than those recommended in **Table 1** may be used, provided the basic stress characteristics are determined.

4 Moisture Content in Timber

The moisture content of timber for various positions in buildings shall be as given in **Table3.**

5 Sawn Timber

5.1 Sizes

Preferred cut sizes of timber for use in structural components shall be as given in **Tables 4, 5, 6 and 7.**

5.2 Tolerances

Permissible tolerances in measurements of cut sizes of structural timber shall be as follows :

a) For width and thickness :

1) Up to and including 100 mm +3 mm
-0 mm

2) Above 100 mm +6 mm
-3 mm

b) For length : +10 mm
- 0 mm

5.3 Location of Defects

The influence of defects in timber is different for different locations in the structural element. Therefore these should be so placed during construction so that they do not have any adverse effect on the members.

Table 1 : Classification of Woods According to Characteristics

S.No.	KINDS OF WOODS	SCIENTIFIC NAMES	Weight (12% moisture content) (lb/cft)	Hard ness	Shear Strengt h	Strength as a beam	Stiffness as a beam	Suitabili ty as a post	Shock resisting ability	Retention shape	Decay resistance	Freedom from objectionable knots	Freedom from shrinkage	Freedom from warping	Paint holding quality	Nail holding quality	Ease of Work ing	DISTINCTIVE USES
1	SAL (AGRAKH)	Shorea robusta	56	100	100	100	100	100	100	100	A	A	A	A	B	A	B	Beams, posts, girders, rallway sleeper, door frames etc.
2	SISAU	Dalbergia Sissoo	50	79	83	86	82	77	97	133	A	A	A	A	B	A	B	Doors, Windows, rallway carriages, cart-wheels, Furnitures etc.
3	KHOTE SALLA	Pinus longlfolla	33	30	47	59	73	64	55	177	C	C	B	B	B	B	B	Beams, rafter, post for cheap houses, boares, cheap furnitures
4	GOBRE SALLA	Pinus excelsa	32	24	43	50	55	55	38	125	C	B	C	B	A	C	A	Picture Frames, Packing box, cheap furniture, boards etc.
5	UTTIS (red)	Alnus nepalensis	36	-							C	A	B	B	A	B	B	Ordinary furnitures, suitablef for curved leg.
6	UTTIS (white)	Aluns nitida	34	-							C	B	C	B	A	C	A	Partition boards, boxes, furnitures etc.
7	CHAMP	Michella champaca	33	-							B	A	B	A	A	A	A	Good furnitures, Door Panels, Carvings etc.
8	SATISAL	Dalbergia latlfolla	38	-							A	A	A	A	B	A	B	Hukka, smoking pipe, susical instruments etc.
9	ASNA	Terminalla Tomentosa	46	91	77	95	100	86	90	108	B	A	B	B	A	B	B	Doors, Windosn, Cabinets' Furniture.
10	PHALAT	Quercus glauca	60	-							B	A	B	C	C	A	C	Handles for tools.
11	TOONI	Cedrella toona	37	39	67	50	59	55	41	108	B	C	A	A	A	B	A	Furnitures
12	SEMAL	Bombax malabaricum	25	21	37	41	41	41	38	150	C	A	C	C	A	C	A	Packing box, boards match sticks, plywood.
13	OKHAR	Juglans regia	45	-							A	B	A	A	A	A	C	Fifle buts, Cabints for grammo-phones, high class furnitures.
14	OAK	Quercus incana	64	-							A	C	C	C	A	A	C	Handles of implements
15	KHAIR	Acacla catechu	60	-							B	A	B	B	A	A	B	Musical durms
16	BIJYASAL	Pterocarpus marsuplum	49	82	77		86	86	93	125	B	A	B	B	B	B	A	Wooden vases, tumblers of

Note:
1. Strength properties taking SAL =100
2. Working behaviours and characteristicc
A = Relatively high
B = Intermediate
C = Relatively low in particular respect listed
3. Source : HMG Dept. of Forestry

Table 2 : Structural Properties & Safe Working Stresses for Some Indian Timbers **

Trade Name	Average Density@12%M.C. (kg/m^2)	Modulus of elasticity All grades (N/mm^2)	Binding & Tension Along Grains, Fb, Ft. Extreme Fibre Stress			Shear Fs		Compression						Remarks
								Parallel to grain 'p'			Perpendicular to grain 'q'			
			In Location ((N/mm^2)	Out Location (N/mm^2)	Wet Location (N/mm^2)	Horizontal in beams, All Locations (N/mm^2)	Along grain All Location (N/mm^2)	Inside Location (N/mm^2)	Outside Location (N/mm^2)	Wet Location (N/mm^2)	Inside Location (N/mm^2)	Inside Locatio n (N/mm^2)	Wet Locatio n (N/mm^2)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		X10^3												
Babul	785.0	10.6	i7.9	15.1	12.2	1.5	2.2	11.0	10.0	7.8	6.4	4.9	4.0	III S2 P2 A1*
Bakli[1]	930.0	11.2	16.5	13.7	11.0	1.2	1.7	9.2	8.2	6.9	5.4	4.2	3.4	III S2 P3 A1 D1
Chir	575.0	9.6	8.2	6.9	5.9	0.6	0.9	6.3	5.5	4.5	2.2	1.7	1.4	III S1 P3 A2 D2
Deodar	545.0	9.3	10	8.6	6.9	0.7	1	7.7	6.9	5.5	2.6	2.1	1.7	I S1 P1 A21D2
Dhaman	730.0	11.8	15.2	12.8	10	1.4	2	8.9	7.9	6.6	4	3.1	2.6	S3 P2 A1 D1
Shisham[2]	755.0	9.1	16.5	13.7	11	1.2	1.7	10.4	9	7.7	6.3	4.9	4	1 P1 A1 D1
Jack	595.0	8	12.4	10.4	8.2	1	1.4	8.2	7.3	5.9	4.5	3.5	2.8	I
Jaman	850.0	11	14.8	12.4	10	1.2	1.7	8.9	8.2	6.6	5.7	4.4	3.5	II S3 P2 A1
Mango	690.0	8.9	12.2	10	7.8	0.9	1.4	7.3	6.5	5.1	3	2.4	1.9	III S2 P3 A2
Sain[3]	850.0	10.9	15.1	12.8	10	1	1.5	9.2	8.2	6.9	5.4	4.1	3.3	II S3 P2 A1 D1
Sal	865.0	12.5	16.5	13.7	11	0.9	1.3	10.4	9.2	7.7	4.4	3.4	2.8	I S3 P1 A1 D1
Sandan	850.0	8.4	13.1	11	8.6	1.2	1.7	8.2	7.3	6.3	4.9	3.8	3.1	I S2 P2 A1 D1
Sisso	787.0	8.7	14.9	12.4	10	1.2	1.7	9.2	8.2	6.5	4.5	3.5	2.8	II
Teak	640.0	9.4	13.7	11.4	9.2	1	1.4	8.6	7.7	6.3	3.9	3	2.5	1 S3 P1 A1 D1

SYMBOLS USED IN ABOVE TABLE **1 Axle wood** **2 Indian Rosewood** **3 Laurel**

I - for High durability Life, that is > = 120 months
II - for Moderate durability Life, that is 60 to 120 months
III - for Low durability Life, that is < 60 months
S1 - Scarcely refractory woods; Those which can be rapidly seasoned without seasoning defects. If not rapidly dried, they develop blue stain and mould on the surface.
S2 - Highly refractory wood: Those which are slow and difficult to season free from seasoning defects.
A1 - Ist choice for beams, rafters, purlins and trusses
D1 - Ist choice for struts and columns.
P1 - Heartwood, non- durable and requires through preservative treatment.

Note : Sapwood of all species requires preservative treatment.

** This table is reproduced from the book "Masonry and Timber structure including Earthquake Resistance Design" with due permission from the author Dr. Anand S Arya. (Permission taken by Mr. Amrit M. Tuladhar)

Table 3 : Data for Nailed Joints *

Wood		With drawal Resistance		Permissible Lateral Strength per nail in double shear in N						Nail Data		
				3.55 mm dia 80 mm long			5 mm dia 150 mm long					
		Specific Gravity	247 G5/2	Permanent Construction		Temp. Construction All	Permanent Construction		Temp. Construction All	Gauge of Nail	Diameter	Available Length
				Lengthening	Node		Lengthening	Node			mm	mm
1		2	3	4	5	6	7	8	9	10	11	12
Babul	(H)	0.835	157	1500	1100	3400	2700	1350	5300	1	727	228
Black Siris	(H)	0.735	114				2750	1750	4500	2	700	228
Chir	(S)	0.575	62	1100	1000	1600	1650	1500	2400	3	640	178
Deodar	(S)	0.56	58	960	400	1500				4	589	152
Dhaman	(H)	0.755	122	1300	500	2400				5	538	127,152
Indian Rose Wood (Shisham)	(H)	0.755	122							6	488	102,111,127,152
Jack	(S)	0.595	67							7	447	89,102
Jaman	(H)	0.85	164	1500	1200	2500	1800	1450	3850	8	406	75,89
Mango	(S)	0.655	86	1100	900	1600	2250	1500	3200	9	366	68,76
Mesua	(H)	0.969	222	2600	800	4100	3900	1550	5750	10	325	51,57,68,76
Oak	(H)	0.865	171	1100	1100	2700				11	294	51,67,63
Sain	(H)	0.88	179	1600	1600	2900				12	264	38,44,51
Sal	(H)	0.800	141	1000	500	1900	1950	1700	3700	113	234	38,44
Sandan	(H)	0.865	171	1700	1100	1800				4	293	25,32,38,44
Sisso	(H)	0.77	128				1700	1500	4300	1	162	25,32
Teak	(H)	0.625	76	1400	800	1300	2800	1300	3003	18	122	19,25

(H) = Hardwood, preboring necessary. (S) = Softwood, perboring not necessary.

* This table is reproduced from the book "Masonry and Timber structure including Earthquake Resistance Design" with due permission from the auther Dr. Anand S. Arya. (Permission taken by Mr. Amrit M. Tuladhar)

6 Design Considerations

6.1 Design Consideration

The provisions in clauses 6.1 to 6.6.2 of IS : 883 – 1970 shall be applicable in additional to following clauses :

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, without exceeding the limits of stress specified stresses, the worst combination of all loadings.

6.2 Loads

6.2.1 Load Combination

The worst combination and location of loads shall be considered for design. Wind and seismic forces shall not be considered to act simultaneously. For calculation of occupancy loads, refer to **NBC 103 – Occupancy Loads.**

6.3 Flexural Members

6.3.1 Effective Span

The effective span shall be taken equal to the clear span plus one half of the required length of bearing at each end. For continuous beam, the effective span may be taken equal to the distance between centres of bearings.

6.3.2 Form Factors for Flexural Members

For larger depth of single log beam, the allowable bending stress in compression will be reduced by multiplying with a form factor K_3 as given in the following where *D* is the depth of beam in mm :

$$K_3 = 0.81 \frac{D^2+89400}{D^2+55000}$$

*For box and I - shape beams :

$$K_4 = 0.8 + 0.8Y \left(\frac{D^2+89400}{D^2+55000} -1 \right)$$

*****Reproduced from ”Masonry and Timber Structure including Earthquake-Resistant Design” by Dr. AS Aryal, with the author’s permission.

Where :

$Y = p1^2 (6 - 8p1 + 3p1^2)(1 - q1) + q1$

$p1$ = ratio of thickness of compression flange to the depth of beam

$q1$ = ratio of thickness of web or webs to the width of the beam.

Note :

i) For solid circular cross sections, the form factor K_5 shall be taken as 1.18.

ii) For square cross-sections where the load is in the direction of diagonal, the form factor K_6 shall be taken as 1.414.

6.4 Deflection

The maximum deflection specified is 1/360 of span when the beam supports brittle covering like asbestos cement sheets, earthenware, slates, gypsum, etc. Otherwise, the maximum deflection shall be 1/240 of span. In the case of cantilever, the deflection should not exceed 1/180 of clear overhang.

It can be shown that, for uniform loads, the depth of a beam, D, which will give safe deflection can be obtained from the following expression :

For maximum deflection of 1/360 of the span :

$$D \geq (75\, F_b/E)\, L$$

For maximum deflection of 1/240 of the span :

$$D \geq (50\, F_b/E)\, L$$

where :

F_b is the actual bending stress in beams

L is the span of the beam

7 Columns

7.1 Solid Columns

These are classified into three categories - i) Short, ii) Intermediate, iii) Long-Solid column depending upon their slenderness ratios (ratio of overall unsupported length l to the dimension of least side, d). For circular section, least side d is taken equal to the side of a square of equal area. Therefore, for a column of diameter *D*, the least side *d* will be equal to :

$$\sqrt{(\lambda\ /\ 4)D\ 2} = 0.88$$

7.2 Long Columns

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

$$f_c = \frac{0.329E}{(S/d)2}$$

Where S/d is the slenderness ratio.

7.3 Slenderness Ratio

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

7.4 Permissible Load

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.

8 Design of Common Steel Wire Nail Joints

8.1 Dimensions of Members

The dimension of an individual piece of timber (that is any single member) shall be within the range given below :

8.1.1 Minimum Thickness

Minimum thickness of any individual member : 30 mm for main members in mono-chord construction; 20 mm for web members and 25 mm for chord members in split-chord construction.

8.1.2 Maximum Thickness

Maximum thickness (other than spacer blocks) : 100 mm. For spacer blocks, not more than three times the thickness of the main elements.

8.1.3 Minimum Depth

Minimum depth of member : 75 mm for chord members and 40 mm for web members of trusses in soft or hard woods.

8.2 Length of Member

Length of members : 4.5 to 5 m maximum in single piece, because longer members are difficult to obtain and are costly.

8.3 Width of Members

Width of any individual piece : not to exceed about eight times its thickness.

8.4 Spacing

The space between two adjacent pieces of timber shall be restricted to a maximum of three times the thickness of the individual piece of timber of the chord member. In case of web members, it may be greater for facilities jointing.

8.5 Lengthening Joint

It is preferable that no lengthening-joint shall be located at a panel point. Generally, not more than two, but preferably not more than one, lengthening-joint shall be permitted between the two panel joints of a member.

8.6 Specification and Diameter of Nails

8.6.1 Nails

Common wire nails shall be made of mild steel having a minimum tensile ultimate strength of 550 N/mm^2.

8.6.2 Nails Diameter

Nail diameter shall be between 1/11 and 1/6 of the least thickest of the members to be connected.

8.6.3 Nails Length

The length of a nail shall be at least 2.5 times the thickness of the thinnest member and it shall penetrate the thicker member by 1.5 times the thickness of the thinner member,or2/3 of thicker member, whichever is further.

8.6.4 Number of Nails

The number of nails in a group should not exceed 10 in one row in the direction of the force.

8.6.5 Spacing of Nails

The minimum spacing of nails having a shank diameter *n* in lengthening-joints should be that given below:

No.	Spacing of Nails	Type of Stress in the Joint	Minimum spacing
i)	End distance	Tension Compression	12 n 10 n
ii)	In the direction of grain	Tension Compression	10 n 5 n
iii)	Edge distance between row of nails perpendicular to the grain	Tension Compression	5 n 5 n

Table 2: Minimum Nail Spacing

Note :

The 5 n distances between rows perpendicular to the grain may be increased subject to the availability of width of the member keeping edge distance constant.

9 Design of Bolted Joints

9.1 General

For total prefabrication, bolt-jointed construction most befits structural timber components. Bolt-jointed construction units give better facilities with respect to workshop ease, transport convenience and re-assembly at site of work site. This technique is base-suited for defence purposes for semi-permanent structures (e.g., sheds) which are required to be erected at high altitudes and in remote locations. Mass - production of structural components in factories can thus be made far more rationally.

9.2 Design Considerations

Where a number of bolts are used in a joint, the allowable load in withdrawal or lateral resistance shall be the sum of the allowable loads for the individual bolts.

9.3 Arrangement of Bolts

The following spacings in bolted joints shall be followed :

a) Spacing of bolts in a row :

For loading parallel and perpendicular to grain loading : 4 d_3.

b) Spacing between rows of bolts :

1) For loading perpendicular to the grain: 2.5 d_3 to 5 d_3 (2.5 d_3 for t/d_3 ratio of 2 and 5 d_3 for t/d_3 ratio of 6), where t is thickness of main member and d_3 is the diameter of the bolt used.

2) For parallel-to-grain loading: At least (N-4) d_3, with a minimum of 2.5 d_3, where N is total number of bolts. The spacing is also governed by net area at the critical section which should be 80 percent of the total area in bearing under all bolts.

c) Edge Distance :

1) For parallel-to-grain loading 1.5 d_3, or half the distance between rows of bolts, whichever is greater.

2) For perpendicular-to-grain loading: the loaded edge distance shall be at least 4 d_3

9.3.1 Spacing

For inclined members, the spacing given above for perpendicular and parallel-to-grain of wood may be used as a guide and bolts arranged at the joint with respect to loading direction.

The bolts shall be arranged in such that the centre of resistance of the bolts passes through the intersection of the centre-of-gravity axes of the members.

9.3.2 Staggering

Staggering of bolts shall be avoided as far as possible in the cases where members are loaded parallel to the grain of the wood. For loads acting perpendicular to grain, staggering is preferable in order to avoid splitting due to weather effects.

9.3.3 Bolt Holes

The bolt holes shall be bored or drilled perpendicular to the surface involved. Forcible driving of the bolts shall be avoided which may cause cracking or splitting of members. As a guide, a bolt hole which is 1 mm oversize may be used for pre-boring.

10 Glue Laminated Timber

This type of timber is often used for large span structures when both the available cross-sections and lengths are much limited.

The limitation is overcome by building up large size member out of 25 to 50 mm thick planks by gluing them together so that grain of all planks is in the same direction

This operation requires uniform application of glue while maintaining both the required temperature and applying the necessary pressure.

10.1 Subject to Bending

For best use of laminated timber, high-strength species and select grade timber should use near the extreme fibres of members subject to bending.

Curved members should ordinarily have a minimum radius of curvature of about 130 t where *t* is the maximum thickness (in mm) of lamination used.

Use	Zones			
	I	II	III	IV
Structural elements	12	14	17	20
Doors and windows	10	12	14	16

Table 4 : Recommended Percentage Moisture Content Values

Note :

Zones are defined by annual relative humidities :
Zone I *less than 40 percent,*
Zone II *40 to 50 percent,*
Zone III *50 to 67 percent, and*
Zone IV *more than 67 percent.*

Thickness (mm)	Width (mm)							
20	40	50	60	80	-	-	-	-
25	40	50	60	80	100	120	140	160
30	40	50	60	80	100	120	140	160
40	-	-	60	80	100	120	140	160
50	-	-	60	80	100	120	140	160
60	-	-	-	80	100	120	140	160
80	-	-	-	-	100	120	140	160
100	-	-	-	-	-	120	140	160

Table 5 : Preferred Cut Sizes of Structure Timbers for Roof Trusses (from 3 to 20 metres)

Note: 2

Preferred lengths of timber : 1 m, 1.5 m, 2 m, 2.5 m and 3 m.

Thickness (mm)	Width (mm)						
60	80	100	120	140	160	-	-
80	-	100	120	140	160	-	-
100	-	-	-	140	160	180	200

Table 6 : Preferred Cut Sizes of Structure Timbers for Roof Purlins, Rafters, Floor Beams, etc.

Note :

Preferred lengths of timber : 2 m, 2.5 m, 3 m and 3.5 m.

Thickness (mm)		Width (mm)							
10	-	50	-	80	100	-	-	-	-
15	-	50	-	80	100	120	160	-	-
20	-	-	-	80	100	120	160	-	-
25	-	-	-	80	100	120	160	200	240
30	-	-	-	80	100	120	160	200	240
40	40	50	60	80	100	120	160	200	240
50	-	50	60	80	100	120	160	200	240
60	-	-	-	-	-	120	160	200	240
80	-	-	-	-	100	120	160	200	240

Table 7 : Preferred Cut Sizes of Structure Timbers for Partition Framing and Covering

Notes:

Preferred lengths of timber : 0.5 m, 1 m, 1.5 m and 2 m.

While nailing, the area of the pre-bored hole shall not be taken into account for this purpose.

Type	Location	Permissible Stresses (N/mm²)		
		Group A	Group B	Group C
Bending and Tension Along Grain	Inside Outside Wet	17.8 14.9 11.8	12.1 10.0 7.9	8.2 6.9 5.9
Shear	Horizontal, all locations *	1.2	0.9	0.6
	Along grain, all locations**	1.7	1.3	0.9
Compression Parallel to Grain	Inside Outside Wet	11.8 10.4 8.6	6.9 6.2 5.7	6.3 5.5 4.5
Compression Perpendicular to Grain	Inside Outside Wet	5.9 4.5 3.7	2.2 1.8 1.5	2.2 2.7 1.4

Table 8: Permissible Stresses for Grade 1 Timber

* *The values of horizontal shears to be used only for beams.*
** *In all other cases, values for shear along grain to be used.*