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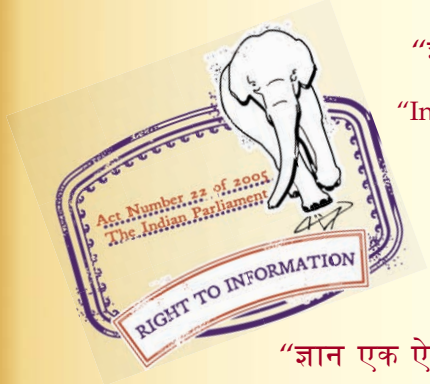
IS 11096 (1984): Code of practice for design and construction of bolt-jointed timber construction [CED 13: Building Construction Practices including Painting, Varnishing and Allied Finishing]



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Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF BOLT JOINTED TIMBER CONSTRUCTION

UDC 694·142·7 : 006·76

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

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February 1985

Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF BOLT JOINTED TIMBER CONSTRUCTION

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(*Continued on page* 13)

Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF BOLT JOINTED TIMBER CONSTRUCTION

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 31 May 1984, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 The prefabricated timber structures find use in defence and industrial sector due to ease in transportation, economy and speed in execution. Bolt-jointed timber construction thus befits pre-cut system of prefabricating structural timber components for semi-permanent structures (sheds) which are required to be erected at high altitudes and in remote places.

0.3 The factors and data in this standard is based on work done by FRI, Dehra Dun using *Hardwickia Binata* (*Anjan*) class C (ordinary group) timbers with mild steel bolts having average yield stress of 345 N/mm^2. The factors and data can be used with other species of timber based on relevant compressive stress values.

0.4 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*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard covers the design, fabrication, finishing and maintenance of bolt jointed timber construction for structural use.

*Rules for rounding off numerical values (*revised*).

2. MATERIALS

2.1 Timber — Timber used for all bolt jointed timber construction shall conform to IS : 3629-1966*. Normally timber seasoned to moisture content as specified for building construction work in IS : 287-1973† shall be used.

2.2 Bolts and Nuts — These shall conform to the requirements of IS : 1363-1967‡. To avoid rusting, use of galvanized bolts and nuts is recommended.

2.3 Washers — These shall conform to IS : 2016-1967§.

3. NECESSARY INFORMATION

3.1 For design and construction of bolt jointed timber units the following information shall be collected:

a) Species and grading of timber,

b) Design data,

c) Moisture content of timber, and

d) Details of treatment.

4. DESIGN CONSIDERATION

4.1 Loads — The loads shall be calculated as given in IS : 875-1964‖. The worst combination and location of load shall be considered for design. Wind and seismic forces shall not be considered to act simultaneously.

4.2 Allowable Stresses — The allowable stresses of timber shall be taken as given in IS : 883-1970¶.

4.3 Dimensions of Members

4.3.1 The minimum thickness of the main member in mono chord construction shall be 40 mm.

4.3.2 The minimum thickness of side members shall be 20 mm and shall be half the thickness of main members.

---

*Specification for structural timber in building.

†Recommendations for maximum permissible moisture content of timber used for different purposes (*second revision*).

‡Specification for black hexagon bolts, nuts and lock nuts (diameter 6 to 39 mm) and black hexagon screws (diameter 6 to 24 mm).

§Specification for plain washers (*first revision*).

‖Code of practice for structural safety of building: Loading standards (*revised*).

¶Code of practice for design of structural timber in building (*third revision*).

4.3.3 The minimum individual thickness of spaced members in split chord construction shall be 20 and 25 mm for web and chord members respectively.

4.4 Bolts

4.4.1 Length of the bolt is the distance from underside of head to the end of threaded portion. The diameter of the bolt in main member should preferably be chosen to give greater length (t) to diameter (d) ratios. There should be more number of small diameter bolts than small number of large diameter bolts in the joint. A minimum of two bolts for nodal joints and four bolts for lengthening joints shall be provided. Bolts should preferably be arranged in horizontal rows i.e. there should be more number of rows rather than bolts in a row.

4.4.2 *Bolt Bearing Strength of Wood* — The allowable load for a bolt in a joint consisting of two members (single shear) shall be taken as one half the allowable loads calculated for a three member joint (double shear) for the same t/d ratio. The percentage of safe working compressive stress of timber on bolted joints for different t/d ratios shall be as given in Table 1.

4.4.2.1 Where a number of bolts are used in a joint, the allowable load shall be the sum of the allowable loads for the individual bolts. The factor for different bolts diameter used in calculating safe bearing stress perpendicular to grain in the joint shall be as given in Table 2. These diameter factors are based on limited tests only and may therefore be considered as tentative.

4.4.3 *Arrangements of Bolts* — The end distance, edge distance and spacing of bolts should be such as given in **4.4.3.1** to **4.4.3.6** (*see* Fig. 1).

4.4.3.1 *Spacing of bolts in row*

For parallel and perpendicular to grain loading — 4 d,

where d = diameter of bolt.

4.4.3.2 *Spacing between rows of bolts*

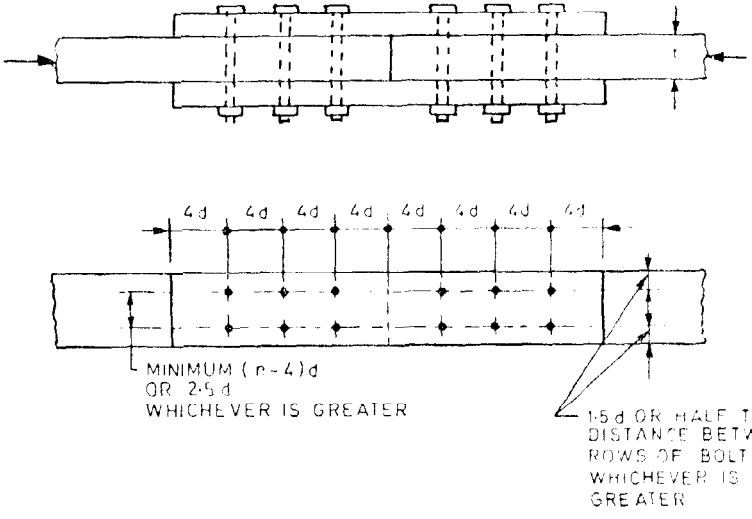
a) *For perpendicular to grain loading* — 2·5 d to 5 d with 2·5 d for t/d ratio of 2 and 5 d for t/d ratio of 6 or more. For ratios between 2 to 6 the spacing shall be obtained by inter-polation.

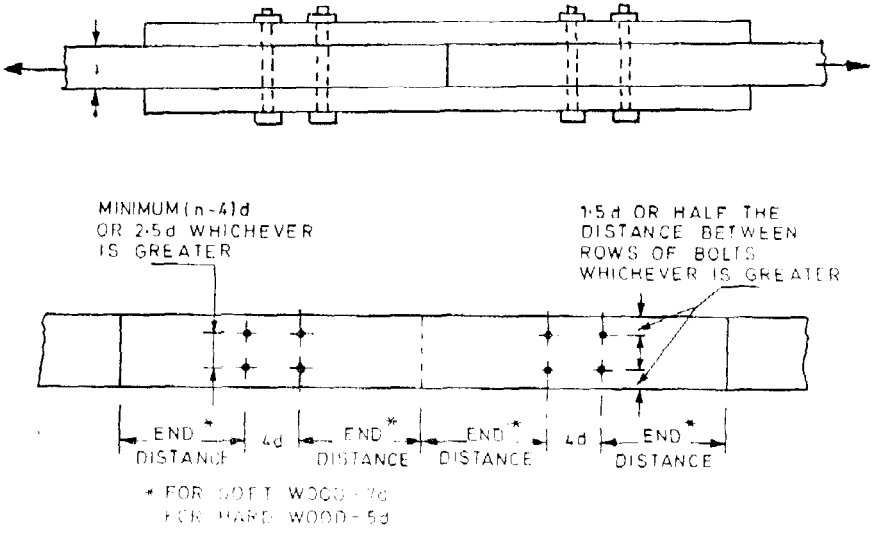
b) *For parallel to grain loading* — At least $(n-4)\,d$ with a minimum of 2·5 d, where n is total number of bolts and d its diameter. Also governed by net area at critical section which should be 80 percent of the total area in bearing under all bolts.

TABLE 1 PERCENTAGE OF SAFE WORKING COMPRESSIVE STRESS OF TIMBER FOR BOLTED JOINTS IN DOUBLE SHEAR

(*Clause* 4.4.2)

t/*d* RATIO	STRESS PERCENTAGE	
	Parallel to Grain (λ_1)	Perpendicular to Grain (λ_2)
(1)	(2)	(3)
1·0	100	100
1·5	100	96
2·0	100	88
2·5	100	80
3·0	100	72
3·5	100	66
4·0	96	60
4·5	90	56
5·0	80	52
5·5	72	49
6·0	65	46
6·5	58	43
7·0	52	40
7·5	46	39
8·0	40	38
8·5	36	36
9·0	34	34
9·5	32	33
10·0	30	31
10·5	—	31
11·0	—	30
11·5	—	30
12·0	—	28

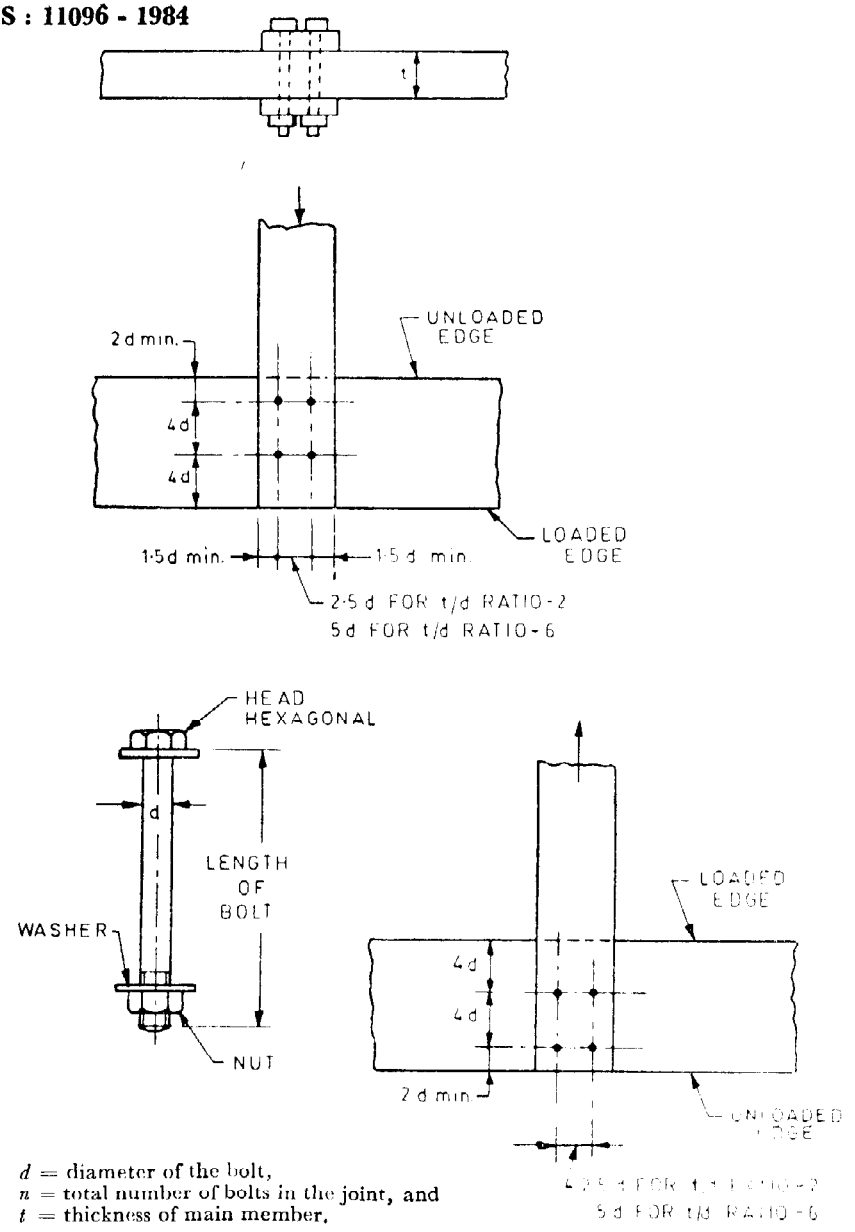




d = diameter of the bolt,
n = total number of bolts in the joint, and
t = thickness of main member.

1A SPACING OF BOLTS IN LENGTHENING JOINTS

FIG. 1 TYPICAL SPACING OF BOLTS IN STRUCTURAL JOINTS — *Contd*



d = diameter of the bolt,
n = total number of bolts in the joint, and
t = thickness of main member.

1B SPACING OF BOLTS AT NODE JOINTS
(JOINTS LOADED PERPENDICULAR TO GRAIN)

FIG. 1 TYPICAL SPACING OF BOLTS IN STRUCTURAL JOINTS

4.4.3.3 *End distance*

a) For soft wood in tension	7 *d*
b) For hard wood in tension	5 *d*
c) For all species in compression	4 *d*

4.4.3.4 *Edge distance*

a) For parallel to grain loading	1·5 *d* or half the distance between rows of bolts whichever is greater
b) For perpendicular to grain loading (loaded edge distance)	4 *d*

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

4.4.3.6 The bolts shall be arranged in such a manner so as to pass the centre of resistance of bolts through the intersection of the gravity axis of the members. Staggering of bolts shall be avoided as far as possible in case of members loaded parallel to grain of wood. For loads acting perpendicular to grain, staggering is preferable to avoid splitting due to weather effects.

TABLE 2 BOLT DIAMETER FACTOR

(*Clause* 4.4.2.1)

Sl No.	Diameter of Bolt	Diameter Factor (*df*)
(1)	(2)	(3)
	mm	
i)	6	5·70
ii)	10	3·60
iii)	12	3·35
iv)	16	3·15
v)	20	3·05
vi)	22	3·00
vii)	25	2·90

4.4.4 A typical outline for design of a bolted joint is given in Appendix A.

4.4.4.1 Bolt bearing strength parellel to grain of wood shall in no case be less than that of perpendicular to grain for use in design calculations. If so, lower of the two values may be adopted.

4.4.4.2 *Service conditions* — Allowable loads calculated apply to bolted joints used under dry service condition as in most covered structures. When a joint is to be used in a location that is continually wet, the allowable load on the bolt may be reduced to one third.

4.4.4.3 *Side members* — Allowable loads calculated are side members of wood and which are each at least one-half the thickness of the main member. If side members are thicker than one-half the thickness of the main member, no increase is allowed. When wood splice plates are used on both sides of timber which is more than twice the thickness of one splice plate, the allowable bolt load shall be computed on the basis that the centre member is exactly twice the thickness of one splice plate, or of the thinner splice plate if the splice plates are not of equal thickness.

4.4.4.4 *Single and multiple shear*

Single shear — The allowable loads for a bolt in a joint consisting of two members only (single shear) shall be one half the allowable load calculated for a 3 member joint having a main member twice the thickness of the thinner member.

Multiple shear — For multiple member joints other than those of two or three members, the allowable load shall vary directly as the number of shear planes involved. The allowable load for each shear planes shall be equal to strength of a two member joint in single shear.

NOTE — Relationship between single and multiple shear is theoretical only.

4.4.4.5 A pre-camber of not less than $\frac{\text{span}}{100}$ shall be provided at the centre of the bottom chord of bolt jointed timber trusses.

5. FABRICATION AND FINISHING

5.1 Different members as well as splice plate/spacer block shall be first prepared to the required size and shall be properly dressed. All the faces of the members shall be given at least one coat of primer in accordance with IS : 2338 (Parts 1 and 2)-1967*. Quantities of bolts, nuts and washers as required shall be procured. Drilling bits of the required diameters to carry out the preboring operation if necessary shall also be procured.

*Code of practice for finishing of wood and wood based materials:
Part 1 Operations and workmanship
Part 2 Schedules.

5.2 Bolting — The holes in the splice plates shall be placed accurately. The holes in the main members are to be centered with those to the splice plates. All the holes are to be bored or drilled perpendicular to the surface involved. The bolt holes shall be of such diameter that the bolts can be driven easily. Forcible driving should be avoided. A bolt hole of 1 mm oversize may be used as a guide for preboring. Washers shall be used between the wood and the bolt head and between the wood and the nut. Washers may not be used if metal splice plates are used.

5.3 The structural unit after fabrication shall be painted in accordance with IS : 2338 (Parts 1 and 2)-1967*.

6. MAINTENANCE

6.1 For structures not exposed to weather periodic painting shall be done after every five year interval.

6.2 For exposed structures enamel painting shall be done after every two years.

6.3 Bolt shall be tightened after one year of completion of structure and subsequently after every two or three years.

APPENDIX A

(*Clause* 4.4.4)

OUTLINE FOR DESIGN OF BOLTED JOINT

A-1. Allowable load on one bolt (unit bearing stress) in a joint with wooden splice plates shall not be greater than the values of P, Q or N as determined by one of the following equations :

a) For loads parallel to grain

$$P = f_{c11} \text{ a } \lambda_1,$$

b) For loads perpendicular (normal) to grain

$$Q = f_{c1} \text{ a } \lambda_2, d_f \text{ and}$$

c) For loads at an angle to grain

$$F = \frac{PQ}{P\sin^2\theta + Q\cos^2\theta}$$ (Hankinson's expression)

*Code of practice for finishing of wood and wood based materials:
Part 1 Operations and workmanship
Part 2 Schedules.

where

P is load on bolt parallel to grain, in N;

Q is load on a bolt perpendicular (normal) to grain, in N;

F is load acting on a bolt at an angle to grain, in N;

f_{c11} is permissible unit stress in compression parallel to grain in N/mm²;

f_{c1} is permissible unit stress in compression perpendicular to grain in N/mm²;

a is projected area of bolt in main member (mm²) = ($t \times d$);

λ_1 is percentage factor for t/d ratio, parallel grain;

λ_2 is percentage factor for t/d ratio, perpendicular to grain;

d_f is bolt diameter factor for perpendicular to grain;

θ is the angle of load to grain direction;

d is diameter of the bolt;

n is total number of bolts in the joint; and

t is thickness of main member.

(*Continued from page* 2)

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INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Baes Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2