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(Reaffirmed 2000)

Indian Standard

METHOD OF TEST FOR NAIL-JOINTED TIMBER TRUSSES

PART I DESTRUCTIVE TEST

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 1

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Indian Standard
METHOD OF TEST FOR NAIL-JOINTED TIMBER TRUSSES

PART I DESTRUCTIVE TEST

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 12 December 1968, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Extensive investigations have been carried out in the Forest Research Institute and Colleges, Dehra Dun on nail-jointed timber trusses fabricated from representative Indian species of timber to test their long-term behaviour under design load, through short-term instantaneous load tests called ' destructive test '. A method for conducting the destructive tests of nail-jointed timber trusses systematically so as to obtain dependable results has now been evolved. To give guidance to the engineers details of this method are given in this standard. The details of nail-jointed construction have been covered in IS : 2366-1963*.

0.3 The main objective of the tests shall be as detailed below:

a) To simulate service conditions of loading on the truss thus determining the strength of members and joints.

b) To determine the stiffness of the truss as a whole and measure the maximum deflection (at various node points of the bottom chord) under loads of varying magnitude as compared to the deflection calculated from the theoretical formula.

c) To evaluate:

  1) apparent factor of safety, and

  2) actual factor of safety.

0.4 A worked example showing the calculations for actual and apparent factors of safety is included in Appendix A.

0.5 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.

*Code of practice for nail-jointed timber construction.

0.6 In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part I) covers the method of destructive test for testing fabricated nail-jointed timber trusses.

2. PROCEDURE OF TEST (EXPERIMENTAL SET-UP)

2.1 Support Conditions — The truss (test specimen) shall be supported either on timber columns or masonry pillars and shall be fixed firmly. Sufficient clearance shall be made available under the bottom chord for observation.

2.2 Loading Arrangement — The arrangement for loading shall be as illustrated in Fig. 1. Loads shall be applied at the top and bottom node points of the truss in the form of hanging platforms to conform to those actually applied in the field of construction.

2.3 Guiding Attachment for Lateral Stability — Guiding attachment shall be provided to keep the lateral stability of the unit under test. This may be done by keeping a similar truss unit placed at suitable distance to simulate rigidity as in actual use brought by attachment of adjacent trusses through purlins and linking both the units together through hinged timber purlins so that the truss under test receives only lateral restraint without any restraint in the vertical deflection.

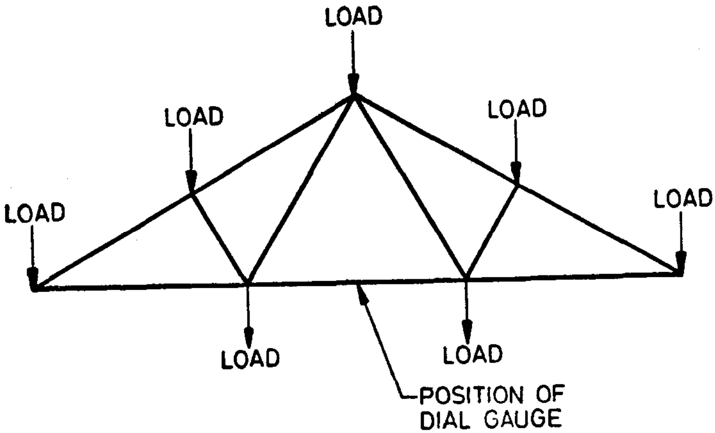
2.4 Deflection Measuring Equipments — Dial gauges shall be fixed at the centre of the bottom chords for recording vertical deflection of the whole truss under test, and also at lengthening joints of bottom chords for measuring longitudinal slip.

3. LOADING

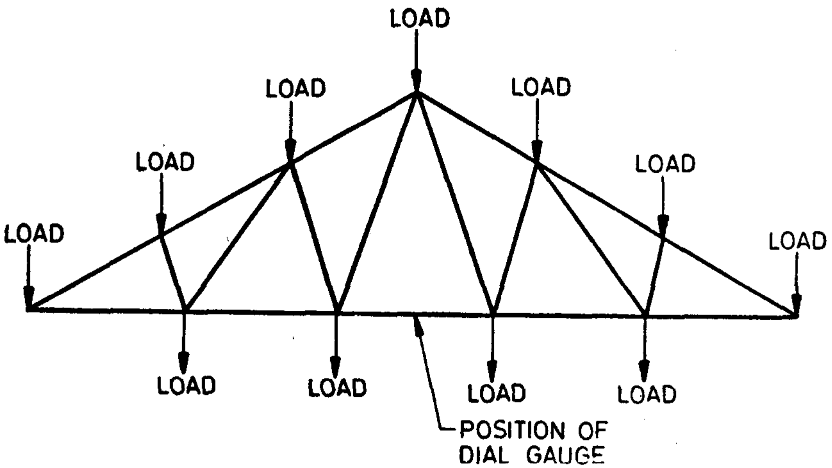
3.1 Rate of Loading — Apply a test load 1·25 times the design load at each of the node points in top and bottom chords in equal increments which is submultiple of the test load (for example, if test load = 100 kg and equal parts are 5, then load increment = 100/5 = 20 kg).

3.2 Period of Loading — Initial test load of 1·25 times the design load shall be applied to the truss. Unloading shall be done after 24 hours. The truss is to be reloaded up to the failure by adding the increased load as mentioned in **3.1** with the time interval of five minutes (interval to allow for setting of the reading) until the failure occurs. In case of ceiling loads, the bottom chord of the truss shall be loaded up to design load and top chord shall be loaded up to the failure by adding increased loads.

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



1A Type of Truss to be Used for Three, Four and Five Metres Spans



1B Type of Truss to be Used for Six Metres Span

Fig. 1 Loading Arrangement for Standard Short Span Timber Trusses

4. OBSERVATIONS

4.1 Record of Deflection — Deflection due to loads shall be recorded in the *pro forma*, as given in Appendix B.

4.2 Record of Failure — The ultimate failure of the truss shall be observed according to its appearance at different points.

5. INTERPRETATION OF DATA

5.1 Apparent Factor of Safety — Apparent factor of safety shall be computed by dividing the total load at failure with the design load. For nail-jointed roof trusses, it shall not be less than 2·5.

5.2 Actual Factor of Safety — Actual factor of safety shall be computed by dividing the maximum force in the member at the time of failure by the maximum calculated permissible force the section can safely take. For nail-jointed roof trusses it shall not be less than 2.

5.3 Allowable Deflection — Allowable deflection in nail-jointed timber trusses shall be computed with the formula given below:

$$\delta = \frac{\Sigma X}{E}$$

where

δ = allowable deflection in cm,

$X = N \frac{(F\,U\,L)}{A}$

E = modulus of elasticity of timber in kg/sq cm,

N = number of planks in a member,

F = force induced in a plank due to design load in kg,

U = force induced in the members of the truss due to unit loading in kg placed where deflection is required to be found out,

L = length of member in cm, and

A = total sectional area of the member in cm^2.

5.4 The actual deflection observed shall be compared with the value of allowable deflection obtained in **5.3**.

6. GENERAL GUIDANCE

6.1 Details are given below:

a) Nail-jointed timber trusses shall be designed conforming to IS : 883-1966*;

b) The two ends of the truss shall be considered fixed at their supports;

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

c) Split-chord construction shall be preferred as it allows the use of higher value of nail strength being in multiple shear;

d) Timber splice plates, if used, shall be provided in such a way that the grain of the plates coincides with the direction of load to be transmitted;

e) The individual thickness of a timber splice plate shall not be kept less than 2 cm as it is liable to split due to atmospheric variations. It is recommended that the total thickness of the side members (or two splice plates) shall be kept 1·5 times the thickness of main member for better behaviour of structural units;

f) The thickness of main member in monochord construction shall not be kept less than 3 cm;

g) The individual thickness of spaced member in split-chord construction shall not be kept less than 2·0 cm in case of web members and 2·5 cm in case of chord members;

h) The space between two spaced members shall be restricted to a maximum of 3 times the individual thickness of the member;

j) Care shall be taken that serious knots, shakes and checks (which are strength reducing defects) do not occupy places where joints are provided;

k) For nail-jointed construction only seasoned timber is recommended. The timber is to be seasoned to an optimum average moisture content which it is liable to experience while in service, so that the effect of atmospheric variation is minimized;

m) Timber distance pieces shall be inserted in the spaced compression member, at a distance of 30 *d*, where '*d*' is the thickness of individual member, with a minimum of one piece at the centre between two node points. In the spaced tension members one spacer piece at the centre is sufficient to keep the integrity and safety of the truss during and after fabrication stages;

n) Better pieces (with lesser strength reducing defects) shall be used for longer tension members or longer compression members;

p) As far as possible, the nails at the joints shall be arranged in such a way that the line of force in the members passes through the centroid of the group of nails transmitting load to it. Where it is not practicable, suitable allowances shall be made for any eccentricity in computing the maximum force in the member;

q) A minimum of two nails at node point and four nails at a lengthening joint shall be provided for the rigidity of a joint;

r) In order to avoid splitting of the members recommended prebore for a particular gauge of nail shall be provided; and

s) Nailing of joints shall be done from both the faces. Protruding nail shall either be cut flush or may be clenched across the grains of timber.

APPENDIX A

(*Clause* 0.4)

EXAMPLE FOR CALCULATION OF APPARENT AND ACTUAL FACTORS OF SAFETY IN CASE OF NAIL-JOINTED TIMBER TRUSSES

A-1. DESIGN

A-1.1 The design data are the following:

a) Species of timber = fir (*Abies pindrow*)

b) Span of the truss = 3 m

c) Total load for which the truss was designed = 420 kg (*see* Fig. 2)

d) Modulus of elasticity of fir timber (E) = 94 000 kg/cm^2

e) Allowable compressive stress parallel to grain for fir timber (f_c'') = 60 kg/cm^2

f) Effective length of top chord between two adjacent node points (l) = 86·6 cm say 85 cm

A-2. CALCULATION OF FACTORS OF SAFETY

A-2.1 Apparent Factor of Safety

Apparent factor of safety at failure = Average ultimate load taken by the truss at failure divided by the total load for which the truss is designed. For nail-jointed timber roof trusses it shall not be less than 2·5

$$= \frac{1\,600}{420}$$

$$= 3{\cdot}81 > 2{\cdot}5$$

A-2.2 Actual Factor of Safety

a) Actual factor of safety at failure = Maximum force produced at the point of failure of the member due to total ultimate load divided by the force the actual section can take at the point of failure. For nail-jointed timber roof trusses it shall not be less than 2.

b) Minimum thickness of the top chord to accommodate one row of nail of 0·37 cm at node joint (*see* Fig. 3)

$$= 20\,d$$
$$= 20 \times 0{\cdot}37$$
$$= 7{\cdot}4$$

c) Assumed size of the chord, therefore, will be 3 × 8 cm $= 24\ \text{cm}^2$

Actually 3 × 7 cm size of the top chord has been provided and tested to destruction, giving ultimate load of 1 600 kg.

Values of constant K (refer to IS : 883-1966*)

$$= 0{\cdot}702\sqrt{\frac{E}{f_c''}}$$
$$= 0{\cdot}702\sqrt{\frac{94\,000}{60}}$$
$$= 27{\cdot}79$$

Slenderness ratio $= \dfrac{l}{d} = \dfrac{85}{3} = 28{\cdot}33$

d) As the value of constant K is less than slenderness ratio, the member is designed as a long column considering it as a fixed member between two node points. Therefore, safe compressive force to be taken by the member:

$$P = A \times \frac{0{\cdot}329 \times E}{\left(\dfrac{l}{d}\right)^2}$$
$$= \frac{(3 \times 8) \times 0{\cdot}329 \times 94\,000\ \text{kg}}{28{\cdot}33 \times 28{\cdot}33}$$
$$= 924{\cdot}48\ \text{kg}$$

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

e) Total ultimate load taken by the truss at failure under destructive test = 1 600 kg (*see* Fig. 4)

Truss failed through the 1st panel of the top chord.

Compressive force transmitted through 1st panel, at ultimate failure (from stress diagrams) = 1 185 kg

Therefore, actual factor of safety $= \frac{1\ 185}{924{\cdot}48}$

$= 1{\cdot}28 < 2$

Therefore, the section is to be increased so as to give a clear factor of safety at least 2 at failure.

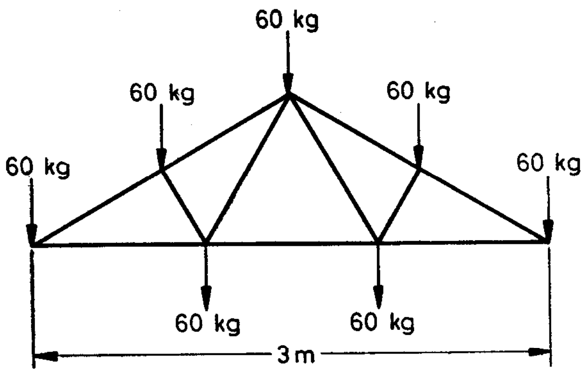


Fig. 2 Timber Truss Loaded with Design Load

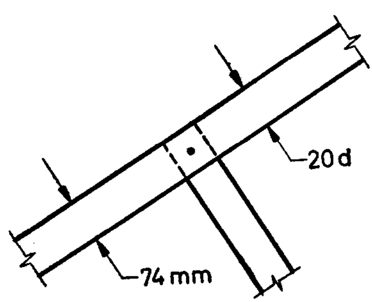


Fig. 3 Portion at Node Joint (Assumed Size of Chord 3×8 cm)

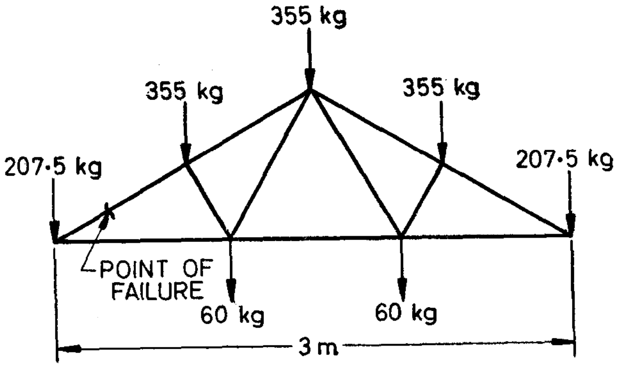


FIG. 4 TIMBER TRUSS AT FAILURE DUE TO ULTIMATE LOAD

APPENDIX B

(*Clause* 4.1)

OBSERVATION ON DESTRUCTIVE TEST

1. Span ....
2. Species ....
3. Average moisture content ....
4. Defects, if any ....

Date ....

No. of test ....

Sl No.	Load at Each Heal Point	Load at Each Node Point	Deflection Reading at the Centre of the Bottom Chord			Horizontal Slip at Lengthening Joints			Time Interval	Re-marks
			Initial	Final	Residual	Initial	Final	Residual		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	kg	kg	mm	mm	mm	mm	mm	mm	minutes	

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