INTERNATIONAL STANDARD

ISO 22389-1

First edition
2010-05-15

Timber structures — Bending strength of I-beams —

Part 1: Testing, evaluation and characterization

Structures en bois — Résistance à la flexion des poutres en I —

Partie 1: Essais, évaluation et caractérisation

Reference number
ISO 22389-1:2010(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22389-1 was prepared by Technical Committee ISO/TC165, *Timber structures*.

ISO 22389 consists of the following part, under the general title *Timber structures — Bending strength of I-beams:*

— *Part 1: Testing, evaluation and characterization*

Component performance and manufacturing requirements is to form the subject of a part 2.

This part of ISO 22389 is based, with permission of ASTM International, on ASTM D 5055, *Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists*, copyright ASTM International.

Introduction

Prefabricated wood-based I-beams are being produced in many countries under different national standards and these products are being exported from one country to another. While the national standards have many similarities, there are also many areas of dissimilarity. Consequently, there is need for the development of an International Standard to establish consistency between these standards to ensure the suitability of prefabricated wood-based I-beams for structural end-use applications regardless of country of manufacture or country of end use. It is intended that the development of this part of ISO 22389 will have value to industry, consumers, governments and distributors.

Timber structures — Bending strength of I-beams —

Part 1:
Testing, evaluation and characterization

1 Scope

This part of ISO 22389 specifies the requirements for prefabricated wood-based I-beams used as structural members in bending applications.

It gives procedures for establishing and evaluating structural capacities of prefabricated wood-based I-beams. The capacities considered are shear, moment, stiffness, bearing, and flange tension and compression. Procedures for establishing common details are given and certain end-use considerations specific to wood-based I-beams are itemized.

Wood-based I-beams tested according to this part of ISO 22389 are intended for use under covered conditions and utilize components that are able to resist the effects of moisture on structural performance due to construction delays or other conditions of similar severity, but are not intended to be permanently exposed to the weather.

This part of ISO 22389 is not applicable to fire performance, formaldehyde requirements and biological durability. It does not cover manufacturing requirements for prefabricated wood-based I-beams.

NOTE Procedures set out in this part of ISO 22389 are applicable to I-beams defined by a standard or a manufacturer's specification that includes requirements for the flanges, webs and bonding, and production controls, including ongoing conformity assessment.

This part of ISO 22389 does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this part of ISO 22389 to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. A specific precautionary statement is given in 5.1.5.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20152-1, *Timber structures — Bond performance of adhesives — Part 1: Basic requirements*

EN 789, *Timber structures — Test methods — Determination of mechanical properties of wood based panels*

ASTM D2915, *Standard Practice for Evaluating Allowable Properties for Grades of Structural Lumber*

ASTM D5456, *Standard Specification for Evaluation of Structural Composite Lumber Products*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
prefabricated wood-based I-beam
structural member manufactured using sawn or structural composite lumber flanges and structural panel webs, forming an "I" cross-sectional shape, bonded together with a structural wood adhesive that possesses the moisture resistance suitable for the conditions specified

NOTE 1 These members are primarily used as joists in floor and roof construction.

NOTE 2 Suitable moisture resistance means resistance under covered conditions and possible exposure to moisture due to construction delays or other conditions of similar severity, but not permanent exposure to the weather.

3.2
characteristic strength and stiffness
population 5th percentile strength value at a 75 % confidence level or the 50th percentile (mean) for bending stiffness value when determined using the test specified in this part of ISO 22389

3.3
structural composite lumber
composite of wood elements bonded with a structural wood adhesive that possesses the moisture resistance suitable for the conditions specified and intended for structural use in dry service conditions

NOTE 1 Examples of wood elements include wood strands, strips, veneer sheets or a combination thereof.

NOTE 2 Suitable moisture resistance means resistance under covered conditions and possible exposure to moisture due to construction delays or other conditions of similar severity, but not permanent exposure to the weather.

4 Materials

4.1 Flange stock

When the flange material is structural composite lumber, the following properties shall be determined in accordance with ASTM D5456 or EN 789:

a) modulus of elasticity;

b) tension parallel to grain;

c) compression parallel to grain;

d) compression perpendicular to grain.

NOTE National standards or governing codes can be applicable to all flange material.

End joints in purchased flange stock are permitted, provided such joints conform to the general intent and 5.8.

4.2 Web material

Web materials covered by this part of ISO 22389 are intended for end-use conditions specified in the Scope (third paragraph) and 3.1, Note 2.

NOTE Manufacturing or performance standards of wood-based panels recognized by national standards or governing codes can be applicable to web materials.

4.3 Adhesives

Adhesives used to fabricate components as well as the finished products shall conform to ISO 20152-1.

NOTE National standards or governing codes can be applicable.

5 Product evaluation

5.1 General

Product evaluation shall be conducted for establishing the characteristic capacities of prefabricated wood-based I-beams for use in building design. In addition, product evaluation shall be conducted for certain common I-beam details since they often influence the I-beam characteristic capacities.

5.1.1 Sample size

The number of specimens specified in this part of ISO 22389 is a minimum. The use of a larger number of samples may be evaluated using ASTM D2915 or an applicable International Standard[1)].

5.1.2 Specimens

Materials and fabrication procedures of specimens shall be as typical of intended production as can be obtained at the time of manufacturing the specimens. Specimens shall be tested at indoor ambient laboratory conditions, which shall be reported.

It is recommended that preliminary tests be conducted to aid the selection of representative specimens.

5.1.3 Test accuracy

Tests in accordance with this part of ISO 22389 shall be conducted in a machine or apparatus calibrated to an error not exceeding ±2,0 %.

5.1.4 Test methods

Methods generally applicable to the full-size I-beam tests required in this part of ISO 22389 shall consider the following:

a) the methods are applicable to both product evaluation and quality control;

b) load rate shall be as specified in the following subclauses;

c) delays between load increments are not required.

5.1.5 Test safety

All full-scale mechanical tests are potentially hazardous and appropriate safety precautions shall be observed at all times. Appropriate lateral restraint shall be provided at all times during full-size I-beam tests to prevent lateral buckling.

1) It is intended to develop an International Standard on the evaluation of characteristic values for structural timber.

5.2 Characteristic shear capacity

5.2.1 Characteristic shear capacity shall be established from test results obtained in accordance with this part of ISO 22389.

5.2.2 Web factors that influence characteristic shear capacities and include web type, thickness, orientation, grade, web to flange joint and joint type in web (machined, butted, glued or not, reinforced), shall be tested in accordance with this subclause.

5.2.2.1 Each combination of these web factors shall be tested separately, unless the critical combination in a proposed grouping is first established by test. Flange stiffness influences characteristic shear capacities.

5.2.2.2 If a range of flange sizes is intended to be used with a given combination of web factors, all sizes shall be tested unless all values are intended to be based on tests with the least stiff flange.

5.2.2.3 When it is intended to group a range of species or grades of either sawn or structural composite lumber flanges, preliminary tests shall be conducted to determine which is critical to the performance of the I-beam.

5.2.2.4 I-beams with structural composite lumber flanges shall be tested separately from joists with sawn lumber flanges.

5.2.3 For each web factor combination identified in 5.2.2, a minimum of 10 specimens shall be tested for each critical joist depth. Critical joist depths are minimum and maximum product depths with approximate 102 mm depth increments in between. If the installation of specific reinforcement, as defined in the manufacturer's handbook, is required at a certain depth to maintain product performance in the progression of a series of depths within a combination, the product shall be tested at this depth plus the adjacent depth, which does not require specific reinforcement.

5.2.4 Specimen length shall be that which usually produces failures in shear and shall not extend past each bearing support by more than 6,4 mm. The bearing length shall be adequate to usually produce shear failure instead of a bearing failure, but shall not exceed 102 mm, unless justified. There shall be a minimum horizontal distance of 1 1/2 times the joist depth between the face of the support and the edge of the load pad.

NOTE Typical I-beam failure modes are shown in Annex B.

5.2.5 On one end of the specimen, a vertical web joint, if used, shall be located approximately 305 mm from the face of the support or half the distance between the support and the load pad.

5.2.6 The load shall be applied to the top flange either as a single-point load at centre span or as two-point loads of equal distance from the centre span. Load pads shall have a sufficient length to prevent local failure.

5.2.7 The load shall be applied at a uniform rate, such that anticipated failure occurs in not less than 1 min.

5.2.8 Any required web reinforcements shall be installed at supports. When required to prevent failure at a load point, additional reinforcement shall be installed, provided such reinforcement is not wider than the load pad.

5.2.9 Ultimate load and mode of failure shall be recorded in addition to product and test set-up descriptions. If any specimen fails in bending, the data shall be excluded. However, for purposes of evaluating characteristic shear capacities, bearing failure may be considered a mode of shear failure.

5.2.10 The dead load of the specimen shall be included in the ultimate load calculation, when specified by the producer.

5.2.11 Mean ultimate shear capacities of an I-beam series or selected grouping of series shall show a linear increase with increasing I-beam depth. A linear regression analysis of the mean values shall have a coefficient of determination, r^2, of at least 0,9, or the specified tests of 5.2.3 shall be repeated. If the second test set fails to meet the criteria, all depths which have been skipped shall also be tested.

5.2.11.1 Data from joist depths where failure is web buckling shall be excluded from the regression analysis, if

a) including the results causes failure to meet the criteria of 5.2.11, or

b) the producer determines the reduction in regression line slope to be unacceptable.

In either case, all depths greater than the shallowest excluded shall be tested.

Depending on joist details and material, there is some depth where web buckling appears as a mode of failure. Further increases in depth will result in consistent web buckling, and at some point, the ultimate shear capacities will be reduced compared to shallower joists.

5.2.11.2 When it is intended to evaluate no more than three depths, the regression analysis is not necessary; nevertheless, each depth shall be tested.

5.2.12 Characteristic shear capacity of the product shall be limited to that calculated by taking into account sample size, test result variability and reduction factors. Data from tests at different joist depths included in the regression analysis are permitted to be combined to obtain a pooled estimate of variability.

5.2.12.1 When combining data, the mean shear capacity, P_e, for depth, d_i, shall be calculated using Equation (1):

$$P_e = A + B\, d_i \tag{1}$$

where A and B are intercept and slope of Equation (1), respectively.

5.2.12.2 Where too few depths are involved for correlation in 5.2.11, the tests fail the regression criteria, or depths are excluded from the correlation, test data shall not be combined and each such depth shall be evaluated separately.

5.2.12.3 The coefficient of variation, $C_{V,i}$, of each individual depth tested shall be calculated using Equation (2):

$$C_{V,i} = \frac{S_i}{\bar{P}_i} \tag{2}$$

where $\bar{P}_i$ and S_i are the mean and standard deviation of the data from each depth tested, respectively.

The coefficient of variation of the combined data sets, C_V, shall be calculated using Equation (3):

$$C_V = \sqrt{\frac{\sum_{i=1}^{J}[(n_i - 1)\, C_{V,i}{}^2]}{\sum_{i=1}^{J} n_i - J}} \tag{3}$$

where

n_i is the number of tests for each depth, d_i, tested and included in the regression analysis;

J is the number of depths included in the regression analysis.

Also, the summation is from $i = 1$ to J.

5.2.12.4 The characteristic shear capacity, P_s, shall be calculated using Equation (4):

$$P_s = P_e - K \times C_V \times P_e \quad (4)$$

where

K is the factor for 5th percentile with 75 % confidence for a normal distribution [from ASTM D2915 or an applicable International Standard[1)]];

P_e is the ultimate mean shear capacity from Equation (1) or the mean of any depth in accordance with 5.2.12.2;

C_V is the coefficient of variation of combined data from Equation (3) or Equation (2), when any depth is evaluated alone.

5.2.12.5 When data are combined, the factor, K, shall be based on a sample size $N = \sum_{i=1}^{J} n_i - J$. When the criteria of 5.2.11 are not met and for depths excluded from the regression analysis, the characteristic shear capacity, P_s, shall be computed separately for each such depth using Equation (5):

$$P_s = (\overline{P}_i - K \times C_{V,i} \times \overline{P}_i) \quad (5)$$

where the factor K shall be based on a sample size of n_i.

5.3 Characteristic bearing capacity

5.3.1 General

5.3.1.1 This subclause provides procedures for establishing the characteristic bearing capacities of prefabricated wood-based I-beams. This subclause does not preclude the development of alternative characteristic bearing capacity evaluation procedures meeting the intent of this part of ISO 22389. If required by national standards or governing codes, documentation showing equivalency to each of the evaluation requirements in this subclause shall be provided.

NOTE This subclause was developed in the light of manufactured products, produced from materials defined in Clause 4. New materials can require new or revised procedures to provide comparable levels of safety and performance.

5.3.1.2 Factors that influence characteristic I-beam bearing capacities, including bearing length, web (type, orientation, thickness and grade), rout geometry, adhesive type, joist depth, flange (type, size, species and grade), and web stiffeners (see 5.3.7), shall be tested in accordance with this subclause.

5.3.1.2.1 Each combination of these factors shall be tested separately according to 5.3.1.4, unless the critical combination is first established by test.

5.3.1.2.2 Joists with structural composite lumber flanges shall be tested and analysed separately from joists with sawn lumber flanges.

5.3.1.3 Testing for both end and intermediate bearing capacities shall be undertaken and analysed as independent test programmes.

5.3.1.4 The minimum sample size for either an end or intermediate bearing capacity evaluation programme shall be 40 for a series of I-beams with the same materials except for the joist depth. The test specimens shall be evenly divided into groups which represent the extremes of bearing length and joist depth for evaluation. Extrapolation beyond the tested extremes of bearing length and joist depth shall not be permitted. Bearing lengths less than 38 mm are not recommended due to concerns regarding construction tolerances and building code requirements.

