TECHNICAL REPORT

ISO/TR 21141

First edition
2022-05

Timber structures — Timber connections and assemblies — Determination of yield and ultimate characteristics and ductility from test data

Structures en bois — Assemblages et composants bois — Détermination des caractéristiques limites et ultimes et de la ductilité à partir des données d'essai

Reference number
ISO/TR 21141:2022(E)

© ISO 2022



COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2022 – All rights reserved

Contents

Page

Foreword ..... **iv**
Introduction ..... **v**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Symbols and abbreviated terms **2**
5 Determination of envelope curves **3**
6 Determination of elastic stiffness **3**
7 Determination of yield point **5**
7.1 Determination of yield load 5
7.2 Determination of yield displacement 7
8 Determination of ultimate limit state **7**
8.1 Ultimate (failure) displacement 7
8.2 Ultimate (failure) load 7
8.3 Equivalent energy elastic-plastic load and stiffness 8
9 Determination of ductility factor **9**
Annex A (informative) **Examples of modelling of envelope curves** **10**
Annex B (informative) **Examples of test data** **12**
Annex C (informative) **Impairment of strength and energy dissipation** **36**
Bibliography **38**

© ISO 2022 – All rights reserved

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 165, *Timber structures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

© ISO 2022 – All rights reserved

Introduction

Timber shows generally brittle failure in tension and bending. This characteristic of wood may cause serious damage to buildings due to the lack of energy dissipation during an earthquake. To avoid such damage, it is expected that the joints connecting wooden members dissipate seismic energy instead of the members themselves. Ductility of a structure is one of the most important factors in dissipating seismic energy. In this technical report, the definitions of yield point, ultimate characteristics and ductility factor used in various test standards are reviewed and methods of determining these characteristics from quasi-static and reversed-cyclic loading test data are compared.

Better fits to envelope curves derived from testing, such as more detailed piecewise linearization are permissible, and indeed desirable for whole building design. The derived load-deflection inputs to structural analysis programs of the various structural elements are only applicable to the case of assessing the maximum connection forces under earthquake loading and provide no guarantee that a structure will remain stable beyond the ultimate strength of the system.

© ISO 2022 – All rights reserved

Timber structures — Timber connections and assemblies — Determination of yield and ultimate characteristics and ductility from test data

1 Scope

The purpose of this document is to extract the methods for determining the yield and ultimate characteristics and ductility of joints and assemblies from test data by reviewing existing standards in Europe, North America and Far East Asia and to provide the basic data for unifying the evaluation methods of parameters by clarifying their similarities and differences.

These parameters are applied for determining the seismic performance of timber structures. This document deals with the method for determining the mechanical properties of individual joints and assemblies, and it does not refer to the seismic performance of the entire structure.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
envelope curve
locus of extremities of the load-displacement hysteresis loops, either obtained separately for the positive and negative loading directions, or obtained by averaging the absolute values of load and displacement of the corresponding positive and negative envelope points for each cycle in the case of a reversed cyclic loading test (see Clause 5)

3.2
stiffness
K_e
resistance to deformation of a specimen in the elastic range, which can be expressed as a slope measured by the ratio of the resisted load, F_1, to the corresponding displacement, V_1 (see Clause 6)

3.3
elastic range
stress range in which a material, upon unloading, will recover the deformation caused by the application of a stress or force

3.4
yield point
point at which a joint or an assembly begins to deform plastically

© ISO 2022 – All rights reserved

3.5
yield load and displacement
F_y, V_y
load and displacement corresponding to the *yield point* (3.4) (see 7.1)

3.6
maximum load
F_{max}
maximum value of the load recorded in a quasi-static test or the maximum value of the load on the average *envelope curve* (3.1) in a reversed-cyclic test or the absolute maximum values of the load recorded in positive and negative directions

3.7
ultimate limit state
failure limit state
state at which a joint or an assembly undergoes a sudden load drop or the load decreases gradually to 80 % of the *maximum load* (3.6), F_{max}, or an excessive deformation (displacement or rotation) occurs (see 8.1 and 8.2)

3.8
ultimate displacement
V_u
failure displacement
displacement corresponding to the *ultimate limit state* (3.7) (see 8.1).

3.9
equivalent energy elastic-plastic curve
EEEP
ideal elastic-plastic curve circumscribing an area equal to the area enclosed by the *envelope curve* (3.1) between the origin, the *ultimate displacement* (3.8), V_u, and the displacement axis (see 8.3)

3.10
equivalent energy elastic-plastic load
F_{eeep}
load corresponding to the upper limit of the *equivalent energy elastic-plastic curve*, *EEEP,* (3.9)

3.11
ductility
ability of joints or assemblies to undergo large amplitude displacement in the plastic range without a substantial reduction of strength

3.12
ductility factor
μ
ratio between *ultimate displacement* (3.8), V_u, and yield displacement, V_y, (see Clause 9).

3.13
equivalent energy elastic-plastic ductility factor
μ_{eeep}
ratio between *ultimate displacement* (3.8), V_u, and EEEP displacement, V_{eeep}, (see Clause 9).

4 Symbols and abbreviated terms

The following symbols and units apply.

F_1, F_2 any load within the elastic range of the curve, expressed in Newtons

F_{eeep} equivalent energy elastic-plastic (EEEP) load, expressed in Newtons

© ISO 2022 – All rights reserved