SLOVENSKI STANDARD
SIST EN 1288-1:2001

01-september-2001

Ugotavljanje upogibne napetosti stekla - 1. del: Uvodno preskušanje stekla

Glass in building - Determination of the bending strength of glass - Part 1: Fundamentals of testing glass

Glas im Bauwesen - Bestimmung der Biegefestigkeit von Glas - Teil 1: Grundlagen

Verre dans la construction - Détermination de la résistance du verre a la flexion - Partie 1: Principes fondamentaux des essais sur le verre

Ta slovenski standard je istoveten z: EN 1288-1:2000

ICS:

81.040.20 Steklo v gradbeništvu Glass in building

SIST EN 1288-1:2001 **en**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1288-1

June 2000

ICS 81.040.20

English version

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This European Standard was approved by CEN on 5 September 1999.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1288-1:2000 E

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 129 "Glass in building", the secretariat of which is held by IBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2000, and conflicting national standards shall be withdrawn at the latest by December 2000.

CEN/TC 129/WG8 "Mechanical Strength" prepared the draft " Glass in Building – Determination of the bending strength of glass – Part 1 : Fundamentals of testing glass".

There are four other parts to this standard:

- Part 2 : Coaxial double ring test on flat specimens with large test surface areas
- Part 3 : Test with specimen supported at two points (four point bending)
- Part 4 : Testing of channel shaped glass
- Part 5 : Coaxial double ring test on flat specimens with small test surface areas

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European standard specifies the determination of the bending strength of monolithic glass for use in buildings. The testing of insulating units or laminated glass is excluded from this standard.

This standard describes:

- considerations to be taken into account when testing glass,
- explanations of the reasons for designing different test methods,
- limitations of the test methods,

and gives pointers to safety requirements for the personnel operating the test equipment.

EN 1288-2, EN 1288-3, EN 1288-4 and EN 1288-5 specify test methods in detail.

The test methods specified in this standard are intended to provide large numbers of bending strength values that can be used as the basis for statistical evaluation of glass strength.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 1288-2	Glass in building - Determination of the bending strength of glass – Part 2 : Coaxial double ring test on flat specimens with large test surface areas
EN 1288-3	Glass in building - Determination of the bending strength of glass – Part 3 : Test with specimen supported at two points (four point bending)
EN 1288-4	Glass in building - Determination of the bending strength of glass – Part 4 : Testing of channel shaped glass
EN 1288-5	Glass in building - Determination of the bending strength of glass – Part 5 : Coaxial double ring test on flat specimens with small test surface areas
EN 572-1	Glass in building - Basic soda lime silicate glass products - Part 1 : Definitions and general physical and mechanical properties
EN 572-2	Glass in building - Basic soda lime silicate glass products - Part 2 : Float glass
EN 572-3	Glass in building - Basic soda lime silicate glass products - Part 3 : Polished wired glass
EN 572-4	Glass in building - Basic soda lime silicate glass products - Part 4 : Drawn sheet glass

EN 572-5	Glass in building - Basic soda lime silicate glass products - Part 5 : Patterned glass
EN 572-6	Glass in building - Basic soda lime silicate glass products - Part 6 : Wired patterned glass
EN 572-7	Glass in building - Basic soda lime silicate glass products - Part 7 : Wired or unwired channel shaped glass
EN 1748-1	Glass in building - Special basic products - Part 1 : Borosilicate glasses
EN 1748-2	Glass in building - Special basic products - Part 2 : Glass ceramics
EN 1863-1	Glass in building – Heat strengthened soda lime silicate glass – Part 1: Definition and description
EN 12150-1	Glass in building – Thermally toughened soda lime silicate safety glass – Part 1: Definition and description
EN 12337-1	Glass in building – Chemically strengthened soda lime silicate glass – Part 1: Definition and description
EN ISO 12543-1	Glass in building - Laminated glass and laminated safety glass - Part 1 : Definitions and description of component parts
prEN 13024-1	Glass in building – Thermally toughened borosilicate safety glass – Part 1: Definition and description

3 Definitions

For the purposes of this European Standard, the following definitions apply:

3.1 flat glass: Any glass product conforming to EN 572-2, EN 572-3, EN 572-4, EN 572-5, EN 572-6, EN 1748-1, EN 1748-2, or any transformed glass made from these products without deliberately inducing profile or curvature.

3.2 bending stress: The tensile bending stress induced in the surface of a specimen.

NOTE: For testing purposes, the bending stress should be uniform over a specified part of the surface.

3.3 effective bending stress: A weighted average of the tensile bending stresses, calculated by applying a factor to take into account non-uniformity of the stress field.

3.4 bending strength: The bending stress or effective bending stress which leads to breakage of the specimen.

3.5 equivalent bending strength: The apparent bending strength of patterned glass, for which the irregularities in the thickness do not allow precise calculation of the bending stress.

3.6 profile bending strength: The quotient of the maximum bending moment and the section modulus of a channel shaped glass. (EN 572-7)

3.7 stress intensity factor: A measure of the stress at a crack tip.

3.8 prestressed glass: Any glass product conforming to EN 1863, EN 12150, EN 12337, prEN 13024.

4 Symbols

F Applied load

h Specimen thickness

L Length of side of square test sample

k Constant for calculation of bending stress in prEN 1288-3

K_1, K_2 Constants for calculation of bending stress in prEN 1288-5

M_{bB} Maximum bending moment

p Gas pressure applied within loading ring in prEN 1288-2

P_{bB} Profile bending strength (of channel shaped glass) = M_{bB}/Z

r_1 Radius of loading ring

r_2 Radius of supporting ring

r_3 Radius of circular specimen

r_{3m} Average specimen radius (for evaluation)

y_0 Central deflection of specimen

Z Section modulus (of channel shaped glass)

μ Poisson number of specimen

NOTE : for soda lime silicate glass (see EN 572-1) a value of 0,23 is used.

σ_b Bending stress

σ_{beff} Effective bending stress

σ_{bB} Bending strength

σ_{beqB} Equivalent bending strength

σ_{rad} Radial stress

σ_T Tangential stress

σ_L Stress in a direction along the length of the specimen

5 Factors to be taken into account when testing glass

5.1 Glass as a material

5.1.1 General

Glass is a homogeneous isotropic material having almost perfect linear-elastic behaviour over its tensile strength range.

Glass has a very high compressive strength and theoretically a very high tensile strength, but the surface of the glass has many irregularities which act as weaknesses when glass is subjected to tensile stress. These irregularities are caused by attack from moisture and by contact with hard materials (e.g. grit) and are continually modified by moisture which is always present in the air.

Tensile strengths of around 10 000 N/mm^2 can be predicted from the molecular structure, but bulk glass normally fails at stresses considerably below 100 N/mm^2.

The presence of the irregularities and their modification by moisture contributes to the properties of glass which need consideration when performing tests of strength.

Because of the very high compressive strength, glass always fails under tensile stress. Since glass in buildings is very rarely used in direct tension, the most important property for load resistance is the tensile bending strength. All the tests described in this standard are intended to evaluate the tensile bending strength of glass.

The bending strength is influenced by the following factors:

a) surface condition (see 5.1.2);

b) rate and duration of loading (see 5.1.3);

c) area of surface stressed in tension (see 5.1.4);

d) ambient medium, through stress corrosion cracking as well as healing of surface damage in the glass (see 5.1.5 and [1] of annex A);

e) age, i.e. time elapsing since the last mechanical surface treatment or modification to simulate damage (see 5.1.6);

f) temperature (see 5.1.7).

The influence exerted by factors b) to f) on bending strength has been taken into account in this standard.

5.1.2 Effect of surface condition

For the purpose of bending strength tests according to this standard, glass behaves as an almost ideally linear-elastic material that fails in a brittle manner. This brittleness means that contact with any hard object can lead to surface damage in the form of ultra-fine, partly submicroscopic cracks and chips. Surface damage of this kind, which is practically unavoidable during normal handling of glass, exerts a notch action which is a major factor in reducing mechanical strength, whereas the chemical composition of the glass has only a minor and in some cases entirely negligible, significance.

Hence it follows that the bending strength determined by the methods referred to in this standard is related largely to the surface condition of the specimen to be tested.

This surface condition is characterized by the following main features.

a) The surface condition imparted by a particular method of treatment, which produces a specific damage spectrum and thus results in a strength which is specific to the finished surface condition;

b) Residual stress, e.g. in the form of thermal or chemical prestress intentionally imparted, as well as unintended residual stresses.

5.1.3 Effect of rate of loading

For the interpretation of the bending strength values determined as described in this standard, the rate of loading is of special importance.

Cracks propagate in glass over a wide range of values of tensile stress (see [2] of annex A). There is a lower limit to the stress intensity factor below which cracks do not propagate (see [1] of annex A). There is then some subcritical crack propagation at higher levels of stress intensity factor, which is influenced by humidity, temperature and chemical agents. Above a critical stress intensity factor crack propagation is very rapid and leads to (almost) instantaneous failure. The consequence of the subcritical crack propagation is, for example, that the rate of load increase and/or the duration of static loading influences the bending strength.

For prestressed glass, this time dependence does not manifest itself until the tensile stress induced in the surface exceeds the compressive stress permanently present there (see [3] of annex A).

5.1.4 Effect of test surface area

The decrease in bending strength of glass with increasing size of the test area exposed to high stress is also of importance (see [4] of annex A). This area effect is accounted for by the statistical distribution of surface defects varying in effectiveness; the larger the test area, the greater is the probability of its containing a large surface defect. Consequently, the influence of the area effect increases with decreasing incidence of defects in the surface, so that this influence is more pronounced in the case of undamaged, e.g. fire-finished glass surfaces (see [5] of annex A).

Differences are likely between the mean values of the bending strength as measured in accordance with EN 1288-2 (maximally stressed area: 240 000 mm^2), or by using devices R45 and R30 in accordance with EN 1288-5 (maximally stressed areas: 254 mm^2 and 113 mm^2), due to the size of the stressed area. Depending on surface damage, the results obtained from testing smaller surface areas may be significantly higher than those obtained from testing larger surface areas, as shown in table 1.

Table 1: Approximate effects of test surface area on the mean measured bending strength

Test Method	Device	Relative bending strength
EN 1288-2	--	100 %
EN 1288-5	R45	140 % to 270 %
EN 1288-5	R30	145 % to 300 %

Since glass for use in buildings is often in large sizes, the test methods specified in EN 1288-2 and EN 1288-3 give values which are more appropriate as the basis for designing flat glass for use in buildings. The test method specified in EN 1288-5 can be useful as a method of evaluating the comparative bending strength of flat glass.

5.1.5 Effect of ambient medium

The surrounding medium in which the glass is tested has an influence on the strength of the glass, particularly if the moisture level is very low. When glass is used in buildings, the relative humidity typically ranges from 30 % to 100 %. Within this range, the effect on the bending strength, as tested according to this standard, is not great. However, tests on glass for use in buildings shall be undertaken in test conditions with relative humidity levels in the range of 40 % to 70 %, in order to eliminate this effect when comparing bending strength results.

5.1.6 Effect of aging

If the glass surface is modified (by abrasion, etching, edge working etc.) before the testing, it is necessary to allow the fresh damage to heal before the test is undertaken. The continual surface modification by moisture affects the damage in a way that can reduce any weakening effect (see [1] of annex A). In practice, glass is highly unlikely to be stressed directly after it has been treated, so it shall be conditioned for at least 24 h before testing.

5.1.7 Effect of temperature

The bending strength of glass is affected by changes in temperature. Within the normal range of temperatures experienced by glass in buildings, this effect is not very significant, but, to avoid possible complications in the comparison of bending strength values, testing shall be undertaken in a restricted range of temperatures.

5.2 Bending stress and bending strength

5.2.1 General

The test methods described in EN 1288-2, EN 1288-3, EN 1288-4 and EN 1288-5 are designed to induce a uniform bending stress over an area (the test area) of the specimen. However, the tests are statically indeterminate, that is, the stresses induced by the applied loads depend on the nature of the material tested as well as the load distribution.