# SLOVENSKI STANDARD
# SIST EN 13031-1:2004

**01-september-2004**

---

**Rastlinjaki – Projektiranje in gradnja – 1. del. Proizvodni rastlinjaki**

Greenhouses - Design and construction - Part 1: Commercial production greenhouses

Gewächshäuser - Bemessung und Konstruktion - Teil 1: Kulturgewächshäuser

Serres - Calcul et construction - Partie 1: Serres de production



**Ta slovenski standard je istoveten z:** **EN 13031-1:2001**

---



**ICS:**

| | | |
|---|---|---|
| 65.040.30 | Rastlinjaki in druge naprave | Greenhouses and other installations |

**SIST EN 13031-1:2004** **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

**EN 13031-1**

December 2001

ICS 65.040.30

English version

# Greenhouses: Design and construction - Part 1: Commercial production greenhouses

Serres: Calcul et construction - Partie 1: Serres de production

Gewächshäuser: Bemessung und Konstruktion - Teil 1: Kulturgewächshäuser

This European Standard was approved by CEN on 7 April 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

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 Management Centre has the same status as the official versions.



CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



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

**Management Centre: rue de Stassart, 36 B-1050 Brussels**



Ref. No. EN 13031-1:2001 E

## Contents

Page

Foreword ..... 3
Introduction ..... 4
1 Scope ..... 5
2 Normative references ..... 5
3 Terms and definitions ..... 6
4 Symbols and abbreviations ..... 7
5 Design of greenhouse structures ..... 9
6 Serviceability limit states ..... 10
7 Ultimate limit states ..... 11
8 Tolerances ..... 12
9 Durability, maintenance and repair ..... 18
10 Actions on greenhouses ..... 18
11 Displacements and deflections (SLS) ..... 23
Annex A (normative) Structural capacity of cladding ..... 30
Annex B (normative) Wind actions ..... 34
Annex C (normative) Snow actions ..... 56
Annex D (normative) Ultimate limit states of arches ..... 60
Annex E (normative) Country related factors, coefficients and formulas ..... 64
Annex F (normative) Owner's manual and identification plaque ..... 83
Annex G (informative) Instructions for maintenance and repair ..... 85
Annex H (informative) Structural detailing ..... 86
Annex I (informative) Calculation method for film covered greenhouses ..... 90
Bibliography ..... 94

## Foreword

This European Standard has been prepared by Techical Committee CEN/TC 284 “Greenhouses”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at te latest by June 2002, and conflicting national standards shall be withdrawn at the latest by June 2002.

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, Soain, Sweden, Switzerland and the United Kingdom.

## Introduction

Part 1 of this standard relates specifically to greenhouses used for the professional production of plants and crops where human occupancy is restricted to low levels of authorised personnel. Other parts of this European Standard are to be prepared that relate to greenhouses where general access by the public is permitted (such as those in garden centres or expositions), and to small domestic greenhouses.

This European Standard gives rules for structural design and construction of greenhouse structures for the professional production of plants and crops.

It is based on ENV 1991 "Eurocode 1: Basis of design and actions on structures" as regards the general principles and requirements for actions, mechanical resistance and stability, serviceability and durability considerations. For structural design considerations, it is similarly based on the relevant parts of ENV 1992 to ENV 1999 (Eurocodes 2 to 9).

Complementary information is provided to account for the particular requirements, functions and forms of commercial production greenhouses that distinguish them from ordinary buildings. Amongst the distinguishing functional requirements of greenhouses are the desire to optimise solar radiation transmission to create and maintain an optimal environment for the growth of plants and crops, and commonly, to support the weight of growing plants. These have implications on the form and structural design of commercial greenhouses. Greenhouse designs, based on this European Standard providing specific information about load distributions, deformation criteria and tolerances, adapting rules of Structural Eurocodes, ENV 1991 to ENV 1999, result in adequate structural safety. This is justified because in contrast to normal buildings, greenhouses have specific design working lives and human occupancy is restricted to low levels of authorised personnel.

As rules and requirements of this Standard may become adopted by other European Standards, for example the Structural Eurocodes or codes for Glass in Building - Design of glass panes, these will be replaced by a reference to the adopting European Standard.

Design criteria for the accessibility of the greenhouses, e.g. ascents, workways, walkways, or roof ladders may be part of national legislation.

## 1 Scope

This European Standard specifies principles and requirements for the mechanical resistance and stability, serviceability and durability for design and construction of commercial production greenhouse structures irrespective of material, including their foundations, for the professional production of plants and crops.

Fire resistance-related aspects are not covered in this standard.

## 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 (including amendments).

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*

ENV 1090-1, *Execution of steel structures - Part 1: General rules and rules for buildings*

EN 1096-1, *Glass in building - Coated glass - Part 1: Definitions and classification*



prEN 1279-1:1998, *Glass in building - Insulating glass units - Part 1: Generalities, dimensional tolerances and rules for the system description*

EN 1863-1, *Glass in building - Heat strengthened soda lime silicate glass – Part 1: Definition and description*



ENV 1991-1:1994, *Eurocode 1 - Basis of design and actions on structures - Part 1: Basis of design*

ENV 1991-2-1, *Eurocode 1: Basis of design and actions on structures - Part 2-1: Densities, self-weight and imposed loads*

ENV 1991-2-3, *Eurocode 1: Basis of design and actions on structures - Part 2-3: Actions on structures - Snow loads*

ENV 1991-2-4, *Eurocode 1: Basis of design and actions on structures - Part 2-4: Actions on structures - Wind actions*

ENV 1992-1-1:1991, *Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings*

ENV 1993-1-1:1992, *Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings*

ENV 1993-1-3:1999, *Eurocode 3: Design of steel structures - Part 1-3: General rules – Supplementary rules for cold formed thin gauge members and sheeting*

ENV 1995-1-1:1993, *Eurocode 5: Design of timber structures - Part 1-1: General rules and rules for buildings*

ENV 1997-1:1994, *Eurocode 7: Geotechnical design- Part 1: General rules*

ENV 1998-1-1:1994, *Eurocode 8: Design provisions for earthquake resistance of structures - Part 1-1: General rules - Seismic actions and general requirements for structures*

ENV 1999-1-1:1998, *Eurocode 9: Design of aluminium structures - Part 1-1: General rules - General rules and rules for buildings*

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 12543-5:1998, *Glass in building - Laminated glass and laminated safety glass - Part 5: Dimensions and edge finishing (ISO 12543-5:1998)*

prEN 13474-1:1999, *Glass in building - Design of glass panes - Part 1: General basis of design*

## 3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in ENV 1991-1 and ENV 1090-1 and the following apply

**3.1**
**greenhouse**
structure used for cultivation and/or protection of plants and crops, that optimises solar radiation transmission under controlled conditions, to improve the growing environment of a size that enables people to work within it.

**3.2**
**commercial production greenhouse**
greenhouse (3.1) for professional production of plants and crops, where human occupancy is restricted to low levels of authorised personnel. Other people shall be accompanied by authorised personnel.

**3.3**
**clearance**
difference between the distance between two opposite cladding bars in their nominal position and the relevant nominal dimension enlarged with the tolerance of a cladding panel.

**3.4**
**dominant permanent opening**
opening which cannot be closed under extreme wind conditions and which has a significant influence on the internal pressure.



**3.5**
**deflection**
the deformation perpendicular to the surface on which the action acts.

**3.6**
**deformation**
change of shape from a building structure or part of it.

**3.7**
**displacement**
change in the position of a point.

## 4 Symbols and abbreviations

The following symbols and abbreviations are used in this European Standard.

$A_i$ accidental action
$a$ largest span of a glass panel, distance between wires
$B$ width
$b$ smallest span of a glass panel, distance in width direction
$c$ clearance, coefficient
$D$ cross sectional dimension of the foundation hole
$d$ distance, diameter
$E$ modulus of elasticity
$F$ force
$f$ strength of a material
$G_i$ permanent action
$H$ height of the ridge above ground level
$h$ length of column (between foundation and gutter)
$L$ length, span
$l$ span, distance in length direction
$M$ moment
$N$ normal force
$n$ number
$p$ permanent action
$Q_i$ variable action
$q$ variable action
$s$ span of a roof
$t$ thickness
$u$ displacement or deflection
$v_{int}$ intended fall of the gutter
$w$ width
$z_e$, $z_i$ reference height of a greenhouse
$\alpha$ angle of pitch
$\alpha_{cr}$ second-order elastic critical load factor
$\alpha_u$ second-order elastic-plastic critical load factor
$\gamma$ partial factor (for actions)
$\Delta$ deviation
$\Delta\varphi$ deviation from intended inclination
$\lambda_{cr}$ lowest positive eigenvalue from linear buckling analysis (Euler)
$\mu$ shape coefficient
$\varphi$ intended inclination
$\phi_x$ rotation angle of the cladding bar
$\psi$ combination coefficient (for actions)

SLS serviceability limit states
ULS ultimate limit states

indices

| | |
|---|---|
| a | arch |
| c | cladding |
| cb | column base |
| f | friction |
| gh | greenhouse |
| gl | glass |
| gw | gable wall |
| h | horizontal |
| lim | limit |
| pe | external pressure |
| pi | internal pressure |
| r | roof |
| s | section length, span |
| sup | support |
| sw | side wall |
| v | vertical |
| wire | wire |

# 5 Design of greenhouse structures

## 5.1 General

**5.1.1** Greenhouses shall be designed by verifying that no relevant limit state is exceeded. The relevant limit states to be considered depend on the class of the greenhouse, which is detailed in 5.2.

**5.1.2** Serviceability limit states shall be verified in accordance with clause 6, and ultimate limit states in accordance with clause 7.

**5.1.3** Greenhouses shall be designed such that the requirements for tolerances, durability, maintenance and repair given in clause 8 and clause 9 are satisfied.

## 5.2 Classes of greenhouse structures

### 5.2.1 General

Greenhouses shall be classified in accordance with a minimum design working life for the structure as given in 5.2.2 and the tolerance to frame displacements of the cladding system as given in 5.2.3. The classification is given in 5.2.4.

### 5.2.2 Minimum design working life for the structure

Greenhouse structures shall have a minimum design working life of 15 years, 10 years or 5 years.

### 5.2.3 Tolerance to frame displacements of the cladding system

**5.2.3.1** Greenhouses shall be designated as Class A or Class B depending upon the tolerance to frame displacements of the cladding system, as described in 5.2.3.2, 5.2.3.3 and 5.2.3.4.



**5.2.3.2** Greenhouses in which the cladding system is not tolerant to frame displacements, resulting from the design actions, shall be designated as Class A. Class A greenhouses shall be designed by considering serviceability limit states (SLS) as well as ultimate limit states (ULS).



**5.2.3.3** Greenhouses in which the cladding system is tolerant to frame displacements, resulting from the design actions, may be designated as Class B. Class B greenhouses may be designed by considering ultimate limit states (ULS) only.



**5.2.3.4** In cases where only a part of the greenhouse cladding system is not tolerant to frame displacements, the greenhouse structure shall be designated as Class A. The local displacements of structural components directly carrying only parts of the cladding system that are tolerant to frame displacements need not be checked against serviceability limit state (SLS) criteria.

### 5.2.4 Greenhouse classification

Greenhouses shall be classified as shown in Table 1.

**Table 1 - Greenhouse classification**

| Classification [c] | Minimum design working life | | |
|---|---|---|---|
| | 15 year | 10 year | 5 year |
| Class A [a] | A15 | A10 | - |
| Class B [b d] | B15 | B10 | B5 |

[a] Class A greenhouses shall have a minimum design working life for the structure of either 15 years or 10 years and shall be designated as Class A15 or A10 greenhouse accordingly.
[b] Class B greenhouses shall have a minimum design working life for the structure of 15 years, 10 years or 5 years and shall be designated as Class B15, B10 or B5 greenhouses accordingly.
[c] Greenhouses clad in glass shall have a minimum design working life of not less than 15 years.
[d] Where expensive crops and/or equipment are present in the greenhouse a design working life of at least 10 years is recommended.

# 6 Serviceability limit states

## 6.1 Requirements

**6.1.1** The serviceability of Class A greenhouses, determined in accordance with 6.2 or 6.3, shall be such that the serviceability limit states with respect to displacements and deflections, presented in clause 11, are not exceeded under the design values of actions determined in accordance with clause 10.

## 6.2 Design calculations

**6.2.1** The design calculation methods for serviceability limit states shall be performed in accordance with:

- 4.4 of ENV 1992-1-1:1991 for concrete structures;
- Clause 4 of ENV 1993-1-1:1992 for steel structures;
- Clause 4 of ENV 1993-1-3:1999 for cold formed steel members;
- Clause 4 of ENV 1995-1-1:1993 for timber structures;
- Clause 2 of ENV 1997-1:1994 for geotechnical design;
- Clause 4 of ENV 1999-1-1:1998 for aluminium structures.

**6.2.2** The material properties shall conform to:

- Clause 3 of ENV 1992-1-1:1991 for concrete structures;
- Clause 3 of ENV 1993-1-1:1992 for steel structures;
- Clause 3 of ENV 1993-1-3:1999 for cold formed steel members;
- Clause 3 of ENV 1995-1-1:1993 for timber structures;
- Clause 3 of ENV 1997-1:1994 for geotechnical design;
- Clause 3 of ENV 1999-1-1:1998 for aluminium structures.



**6.2.3** The design calculation methods for and properties of other materials may be used provided it can be demonstrated that the resulting design is suitable for the intended purpose and leads to safe results.



## 6.3 Testing

The serviceability may be determined by testing, provided that the tests are carried out and the test results are evaluated, both in accordance with the procedures described in clause 8 of ENV 1991-1:1994.

# 7 Ultimate limit states

## 7.1 Requirements

**7.1.1** The structural capacity of Class A and Class B greenhouses, determined in accordance with 7.2 or 7.3, shall be such that the ultimate limit states are not exceeded under the design values of actions determined in accordance with clause 10.

**7.1.2** Clamping connections that operate by friction between structural members shall be able to transmit the ultimate limit state design forces without slipping.

## 7.2 Design calculations

**7.2.1** The design calculation methods for ultimate limit states shall be performed in accordance with:

- 4.3 of ENV 1992-1-1:1991 for concrete structures;
- Clause 5 of ENV 1993-1-1:1992 for steel structures;
- Clause 5 of ENV 1993-1-3:1999 for cold formed steel members;
- Clause 5 of ENV 1995-1-1:1993 for timber structures;
- Clause 2 of ENV 1997-1:1997 for geotechnical design;
- Clause 5 of ENV 1999-1-1:1998 for aluminium structures;
- ENV 1991-1 for steel arches;
- Annex A for cladding.

NOTE For steel arches it is referred to ENV 1991-1 because ENV 1993-1-1 does not contain design calculation methods for arches. In Annex D a design calculation method is given based on research results from tests on tubular steel arches for film plastic covered tunnels.



**7.2.2** The material properties shall conform to:

- Clause 3 of ENV 1992-1-1:1991 for concrete structures;
- Clause 3 of ENV 1993-1-1:1992 for steel structures;
- Clause 3 of ENV 1993-1-3:1999 for cold formed steel members;
- Clause 3 of ENV 1995-1-1:1993 for timber structures;
- Clause 3 of ENV 1997-1:1997 for geotechnical design;
- Clause 3 of ENV 1999-1-1:1998 for aluminium structures;
- Annex A for cladding.



**7.2.3** The design calculation methods for and properties of other materials may be used provided it can be demonstrated that the resulting design is suitable for the intended purpose and leads to safe results.

## 7.3 Testing

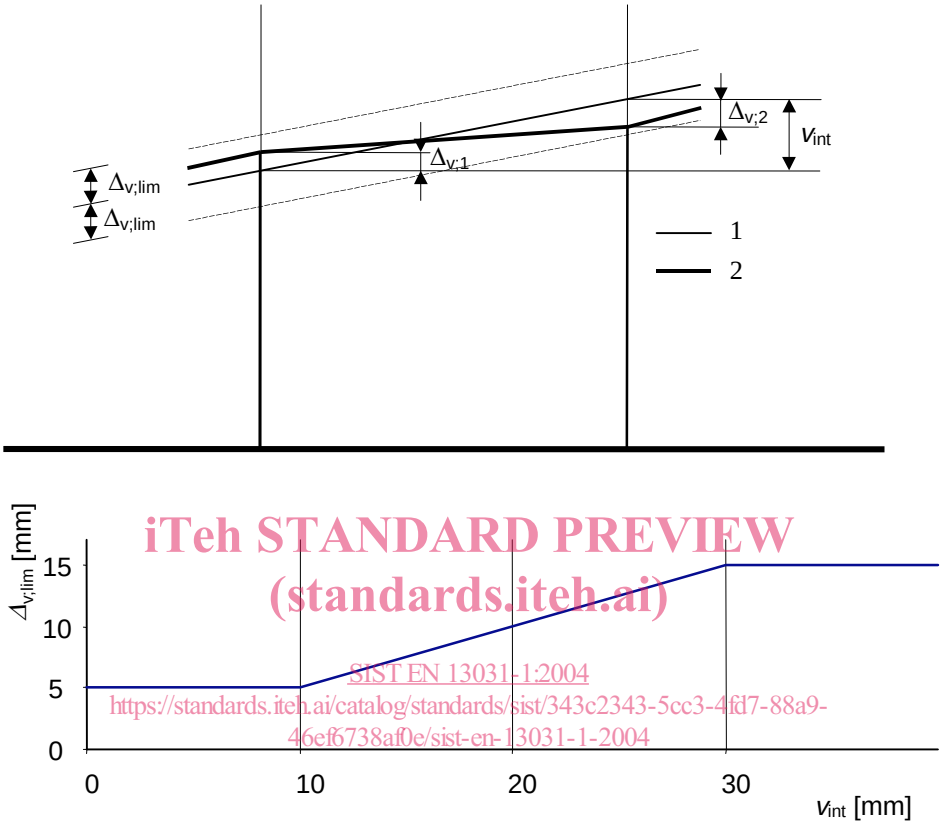
The structural capacity may be determined by testing, provided that the tests are carried out and the test results are evaluated, both in accordance with the procedures described in clause 8 of ENV 1991-1:1994.

# 8 Tolerances

## 8.1 General

**8.1.1** The design calculation methods for greenhouses are valid only if the greenhouse structure conform to 8.1, 8.2 and 8.3.

**8.1.2** The vertical deviation $\Delta_v$ from the intended position of the gutter at column ends shall be not more than $\Delta_{v;lim}$, where $\Delta_{v;lim}$ is equal to half the intended fall $v_{int}$ of the gutter per bay, with a minimum upper limit of 5 mm and a maximum upper limit of 15 mm (see Figure 1).





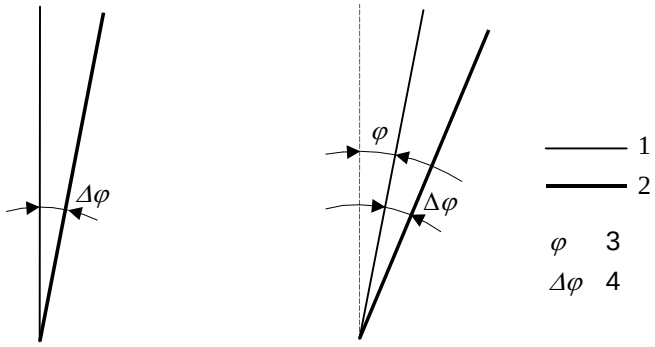

**Key**

1 Intented position
2 Actual position

**Figure 1 - Limit for the vertical deviation from the intended position of the gutter at column ends**

**8.1.3** The deviation from the intended inclination of columns in any direction shall be not more than 1/200 or 20/*h*, whichever is smaller, where *h* is the column length measured between foundation and gutter in millimetres (see Figure 2).

In case the deviation from the intended inclination shall be measured the influence of thermal actions may be taken into account. Unless specified in annex E, the temperature under which the components are made can be taken as 20 °C.




**Key**

1 Intended position in design
2 Actual position
3 Intended inclination
4 Deviation from the intended inclination

**Figure 2 - Deviation from the intended inclination of a column**

**8.1.4** The deviation from the intended inclination of a foundation pile shall be not more than 1/50.

**8.1.5** The position of the prefabricated foundation pile within the foundation hole shall be such that (see Figure 3):



- its centre lies within a circle with radius equal to *D*/5 or 100 mm, whichever is less, of the centre of the foundation hole;



- the distance between the face of the pile and the face of the foundation hole is at least 50 mm or *D*/8, whichever is larger;

where *D* is the cross sectional dimension of the foundation hole.

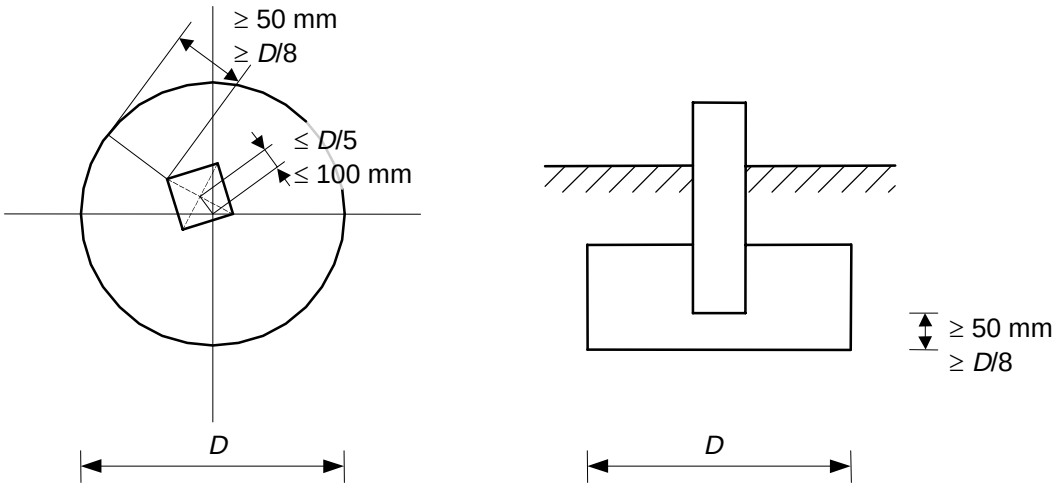



**Figure 3 - Position of the prefabricated foundation pile within the foundation hole**

**8.1.6** The tolerances of glass panels, made of basic soda-lime silicate glass conforming EN 572-1 to EN 572-6, and which are not coated or coated in accordance with EN 1096-1, shall be as follows: