BRITISH STANDARD

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Flexible sheets for waterproofing — Determination of the resistance to wind load of mechanically fastened flexible sheets for roof waterproofing

ICS 91.100.50

BSI
British Standards

National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Flexible sheets for waterproofing - Determination of the resistance to wind load of mechanically fastened flexible sheets for roof waterproofing

Feuilles souples d'étanchéité - Feuilles bitumineuses, en plastique et en caoutchouc destinées à assurer l'étanchéité des toitures - Détermination de la résistance à l'arrachement au vent

Abdichtungsbahnen - Bestimmung des Widerstandes gegen Windlast von mechanisch befestigten Dachabdichtungsbahnen

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Foreword

This document (EN 16002:2010) has been prepared by Technical Committee CEN/TC 254 “Flexible sheets for waterproofing”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by November 2010, and conflicting national standards shall be withdrawn at the latest by November 2010.

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Introduction

The test is performed on a standard test configuration, i.e. a load-bearing structure, a layer of insulation material and the mechanically fastened membrane(s).

For the determination of the performance of the mechanical fastening system (fastener and washer), with or without possible substrates, ETAG 006:2000, Annex D may be used. The suppliers of these mechanical fastening systems should provide the required information.

For the calculation of the performance of wind load resistance of the whole roof, see the relevant national and/or international standards.

The result of this standard is the resistance to wind load of the flexible sheet expressed as the characteristic load per fastener. Safety factors may be defined by national regulation and/or within European or national application documents.

In principle, the test apparatus may also be used to assess (partially) bonded flexible sheets, but some modifications and additional guidance are needed. This is the reason to limit the scope of this standard to mechanically fastened sheets only.

1 Scope

This European Standard specifies a test method to determine the resistance to wind load of mechanically fastened flexible sheets for roof waterproofing.

The assessment is limited to the performance of the mechanically fastened flexible sheets only. The test method does not include the determination of the performance of the mechanical fastener and/or the combination of the mechanical fastener and the substrate.

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.

EN 10346:2009, *Continuously hot-dip coated steel flat products — Technical delivery conditions*

EN 13162, *Thermal insulation products for buildings — Factory made mineral wool (MW) products — Specification*

EN 13416, *Flexible sheets for waterproofing — Bitumen, plastic and rubber sheets for roof waterproofing — Rules for sampling*

EN 13707:2004+A2:2009, *Flexible sheets for waterproofing — Reinforced bitumen sheets for roof waterproofing — Definitions and characteristics*

EN 13956:2005, *Flexible sheet for waterproofing — Plastic and rubber sheets for roof waterproofing — Definitions and characteristics*

ETAG 006:2000, *Guideline for European Technical Approval systems of systems mechanically fastened flexible roof waterproofing membranes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13707:2004+A2:2009 and EN 13956:2005 and the following apply.

3.1
fastener
object to fasten the flexible sheet to a structural deck

NOTE A fastener may be made of a washer, a metal sleeve and a screw or of a plastic washer with an integrated sleeve and a metal shank.

3.2
fastening system
assembly of components intended to secure a waterproofing system to the structural deck by means of point fasteners or linear fasteners

NOTE Whilst primarily intended to secure the covering against wind uplift forces, the system may contribute to securing intermediate layers such as thermal insulation, vapour control layers, etc.

3.3
jointing technique
sealing of at least two layers of flexible sheets for roof waterproofing

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NOTE This may be done by e.g. bond (torch, adhesive) or welding (hot air, chemicals).

3.4
linear fastener
continuous strip or lath perforated by point fasteners intended to secure the flexible sheets for roof waterproofing in the general area of the roof and/or at its perimeter

NOTE The strip or lath is commonly made of metal.

3.5
point fastener
shaft, in form of a screw, nail or expanding anchor, together with a disc-shaped washer or collar

NOTE Forces may be transmitted to the fastener by the clamping action of the washer or by bond between a plastic surface on the washer and a plastic roof covering, or by other means.

3.6
test specimen
representative part of the roof, consisting of one or more layers of flexible sheet for roof waterproofing, an insulation layer and a structural deck

3.7
structural deck
roofing panel which has to transfer both permanent and variable loads to the other construction parts of the roof or building

3.8
vapour control layer
sheet used to limit the transportation of water vapour into any part of the roof

4 Symbols and abbreviations

For the purposes of this document, the following symbols apply.

		Unit
A_i	area of influence of the fastener	mm^2
a	maximum spacing between rows of fasteners	mm
b	maximum spacing between individual fasteners in a row	mm
C_a	geometric correction factor	-
C_d	statistical correction factor	-
g	number of gusts, specified for each "proportional" peak load in a cycle	-
i	proportional part of $P_{100\%;n}$	%
l	length of the test area inside the pressure chamber	mm
m	width of the test area inside the pressure chamber	mm
n_f	number of cycles before failure	-
P_a	applied pressure during the gust	kPa
P_i	peak pressure during the gust	kPa
P_{test}	peak pressure of the cycle preceding the cycle of failure	kPa
$P_{100\%;n}$	peak pressure in the pressure chamber during cycle (n)	kPa

t	time	s
ΔW_a	applied load per fastener	N
ΔW_{char}	characteristic load for the resistance to wind uplift per mechanical fastener	N
ΔW_i	peak load per fastener	N
$\Delta W_{100\%;n}$	peak load per fastener of cycle (n) with n = 1, 2, 3, …, n_f	N
α	number of spaces between rows of fasteners	-
β	number of spaces between fasteners	-

5 Sampling

The flexible sheets for roof waterproofing shall be sampled according to EN 13416.

All additional materials to construct the test specimen such as fasteners, insulation, substrate, vapour control layers, shall be according to the sampling requirements of the relevant European harmonised technical specifications. If these specifications are not available, then sampling shall be done according to the instructions of the applicant.

6 Test conditions

The test specimen and the apparatus shall be conditioned for at least 16 h in an environment of (23 ± 5) °C prior to the test and used under the same conditions.

7 Apparatus and additional devices

7.1 Pressure (vacuum) chamber

The internal length and width of the pressure chamber shall be according to 8.2. The height of the pressure chamber shall be such that the applied pressure is equally distributed and not affected by deformations of the test specimen. The pressure chamber shall be provided with one or more windows in such a way that the test specimen can be observed during testing.

The pressure chamber shall be capable of resisting a suction pressure of 10 kPa. It shall be possible to create an airtight seal between the test specimen and the pressure chamber.

7.2 Fan including control and recording system

7.2.1 Fan and controlling equipment

The combination of the fan and the controlling equipment (e.g. valve) shall be capable of producing the dynamic load cycles, as defined in 9.4.

7.2.2 Pressure measurement device

The pressure measurement device shall have a measurement tolerance less than or equal to ± 1 % in combination with the registration apparatus used.

NOTE The best attainable accuracy of measurement is 0,02 kPa, being the accuracy of measurement of the pressure gauge.

7.2.3 Thermometer

The thermometer shall be capable of measuring between at least 0 °C up to 30 °C with a measurement tolerance less than or equal to ± 1 °C in combination with the registration apparatus used. The thermometer shall be placed at a maximum distance of 0,2 m from the test rig. The thermometer shall be placed on the same level as the test rig with a maximum tolerance of ± 0,2 m.

7.2.4 Chronometer

The chronometer shall be capable of measuring within a range of at least 60 s and have a measurement tolerance less than or equal to ± 0,1 s in combination with the registration apparatus used.

7.2.5 Time and pressure measurement and registration device

The pressure registration device shall be capable of registering and storing the pressure level every 0,1 s during the whole test period.

NOTE 1 This is necessary to prove that the load/time curve as described in Figure 3 has been applied.

The time and pressure measurement and registration device shall be capable of measuring pressure, with an accuracy of measurement less than or equal to 1 % in combination with the reading equipment.

NOTE 2 Guidance on the calibration procedure is given in 7.3.

7.3 Calibration

The calibration of the test equipment shall be carried out at a suction pressure (P_i) of 3 kPa generating a load/time diagram according to Figure 3a) and 6 kPa generating a load/time diagram according to Figure 3b), on a rigid structure with a time tolerance of ± 0,1 s.

8 Test specimen

8.1 General

The number of test specimens shall be one.

The dimensions of the test specimen shall be such that it fits the pressure chamber.

During the test procedure, the test specimen shall have a pitch of (0 ± 2)° or a pitch of (90 ± 2)°.

The test specimen shall have at least 3 rows of fasteners.

8.2 Dimensions of the test area

The minimum effective test area of the test specimen for the wind uplift test shall be 2 m × 2 m. In case one dimension is less than 2 m the area of the test specimen shall at least be 8 m^2.

NOTE 1 The effective test area is equal to the internal dimensions of the pressure chamber.

The dimensions of the test area shall be according to:

$$l \geq \alpha \times a + 200 \text{ with } \alpha > 1 \quad (1)$$

$$m \geq \beta \times b + 400 \text{ with } \beta > 3 \text{ in case } \alpha = 2 \text{ and } \beta > 2 \text{ in case } \alpha > 2 \quad (2)$$

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$$l \geq m \quad (3)$$

where

A_i is the area of influence of the fastener, in square millimetres (see 9.4);

a is the maximum spacing between the rows of fasteners, in millimetres;

b is the spacing between the individual fasteners in a row, in millimetres;

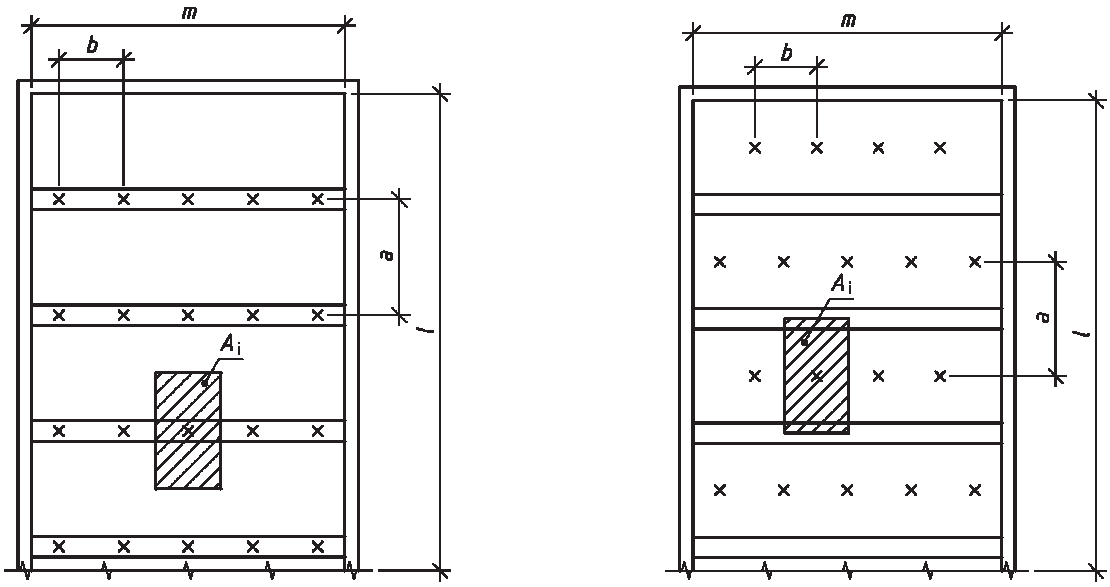
l is the minimum length of the test area, in millimetres;

m is the minimum width of the test area, in millimetres;

α is the number of spaces between the rows of fasteners;

β is the number of spaces between the fasteners.

NOTE 2 For definition of the dimensions see Figure 1.



a) Fasteners placed in the overlapping **b) Fasteners not placed in the overlapping**

Figure 1 — Dimensions of test specimen of mechanically fastened flexible sheets

When the mechanical fasteners are not placed in the overlapping of the sheets and are placed in a regular pattern, the spacing (*a* and *b*) shall be as defined in Figure 1b). In case of an asymmetric fastening pattern, the two fasteners placed close by shall be seen as one fastening, the spacing (b) shall be as defined in Figure 2.

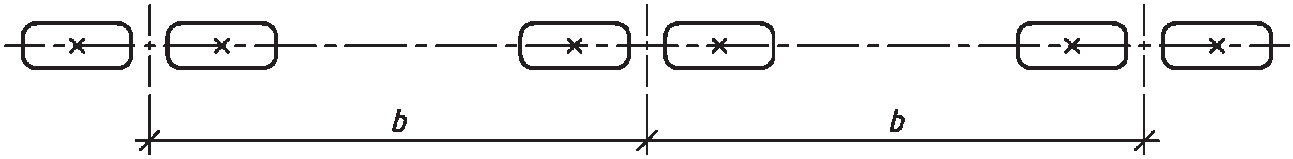


Figure 2 — Definition of spacing *b* in case of an asymmetric fastening pattern

8.3 Flexible sheets

The flexible sheets and fasteners shall be symmetrically positioned in the pressure chamber independently of the width of the sheets. In case an uneven amount of rows of fasteners is used the middle row shall run through the centre of the chamber. The sheets shall be installed according to the manufacturer's installation guide.

8.4 Insulation

A mineral wool insulation board according to EN 13162, loosely laid on the substrate, shall be used having the following specifications:

a) thickness of 100 mm with a thickness tolerance of T2;

b) compressibility level between CS(10)50 and CS(10)70;

c) point load level between PL(5) 500 and PL(5)700.

In case the fastening pattern of the membrane results in one or more loosely laying insulation boards, these loose boards shall be fixed by only one additional fastener.

8.5 Vapour control layers

The test shall be performed without vapour control layers.

NOTE Test results without vapour control layers are valid for applications with vapour control layers (see 11.3).

8.6 Structural deck

As a standard structural deck trapezoidal galvanised steel with the following specifications shall be applied:

a) minimum steel thickness of 0,70 mm;

b) steel type S280GD according to EN 10346:2009.

9 Testing

9.1 Test procedure

The test procedure shall be:

a) conditioning of the test specimen according to Clause 6;

b) assembling airtight the test specimen, pressure chamber and fan including control and recording system according to 8.1 and 9.3;

c) applying the pressure in the pressure chamber according to 9.4;

d) registering the results according to 9.5.

9.2 Load/time diagram of the gust

The applied pressure during the gust, P_a, shall generate a load/time diagram according to Figure 3a) or Figure 3b) such that:

a) for suction pressures below 6 kPa at least 90 % of the peak load ΔW_i shall be reached in the period between 0,7 s and 1,0 s after the loading has been started;

b) for suction pressures of 6 kPa or higher at least 90 % of the peak load ΔW_i shall be reached in the period between 0,7 s and 2,0 s after the loading has been started;

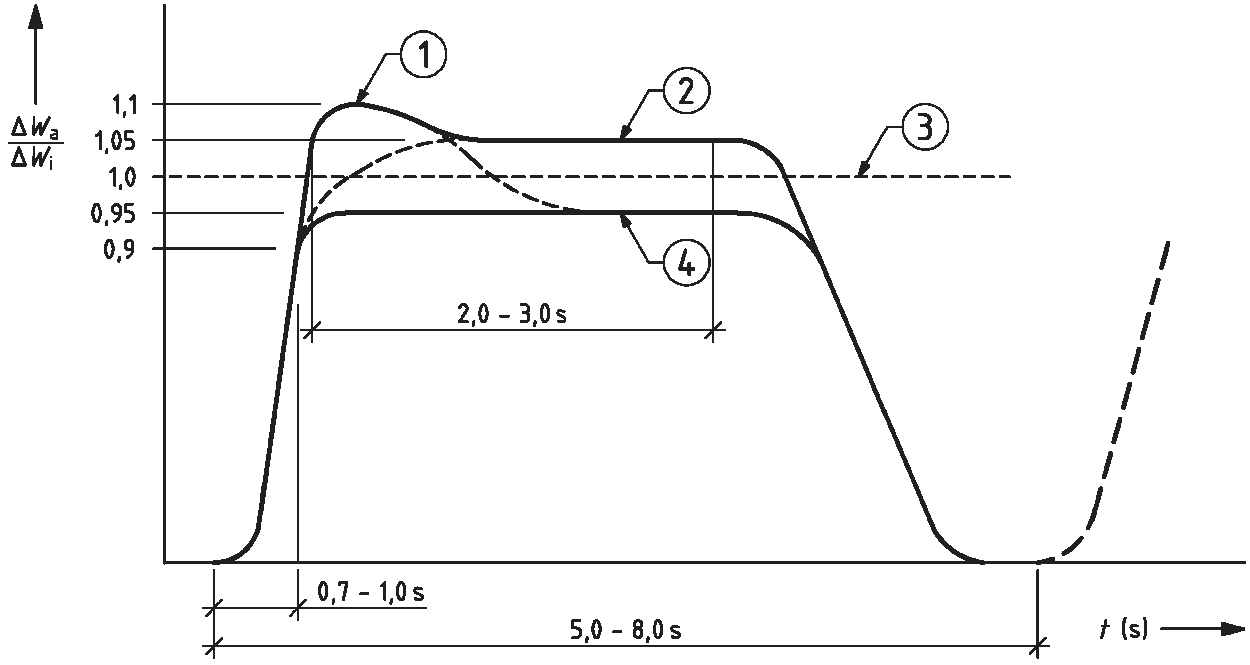
c) the time tolerance is ± 0,1 s;

d) the load inaccuracy of measurement is limited to + 10 % and - 5 % for the first gust of the first cycle;

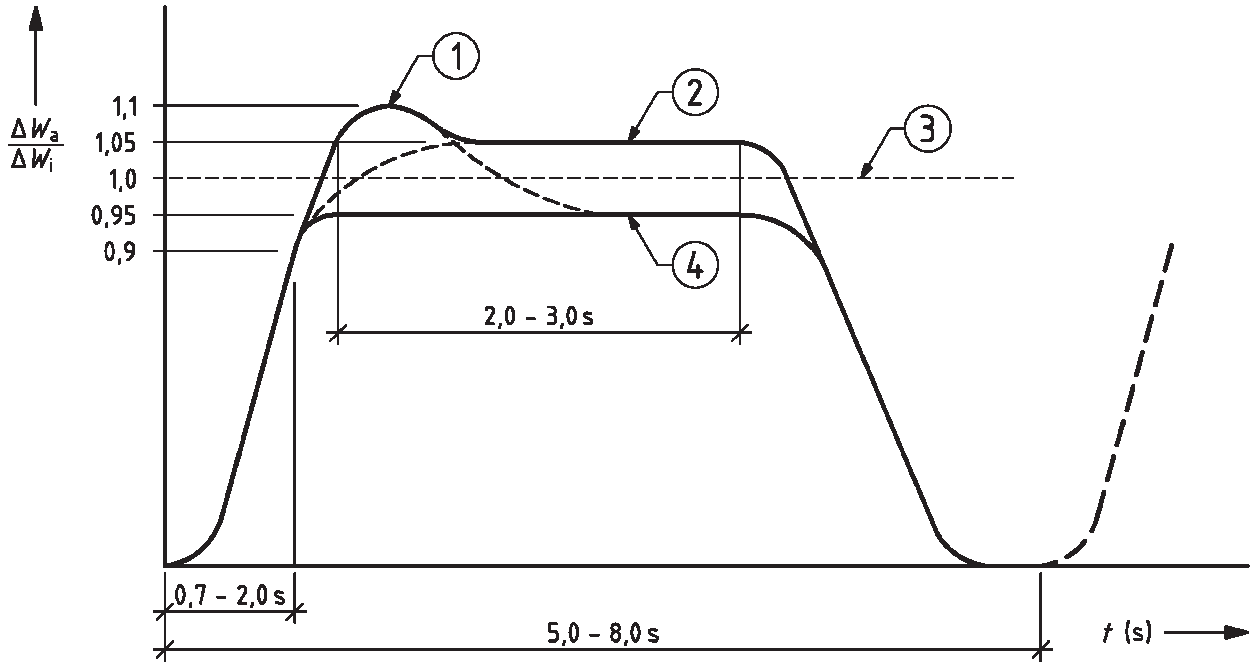
e) the load inaccuracy of measurement is limited to ± 5 % for the rest of the gusts;

f) the load has a value between these plus or minus 5 % boundaries during 2,0 to 3,0 s;

g) the duration of the gust is a maximum of 8 s.



a) For suction pressures below 6 kPa



b) For suction pressures of 6 kPa or higher

Key

)	initial peak load limit (+ 10 %)
(	upper limit (+ 5 %)
)	peak load ΔW_i, in newtons i = 40 %, 60 %, 80 %, 90 %, 100 %
(	lower limit (- 5 %)
t	time in seconds
ΔW_a	applied load per fastener, in newtons
ΔW_i	peak load per fastener, in newtons
i	proportional part of $P_{100\%;n}$ (40 %, 60 %, 80 %, 90 %, 100 %, see 9.4)

Figure 3 — Load/time diagram of a gust

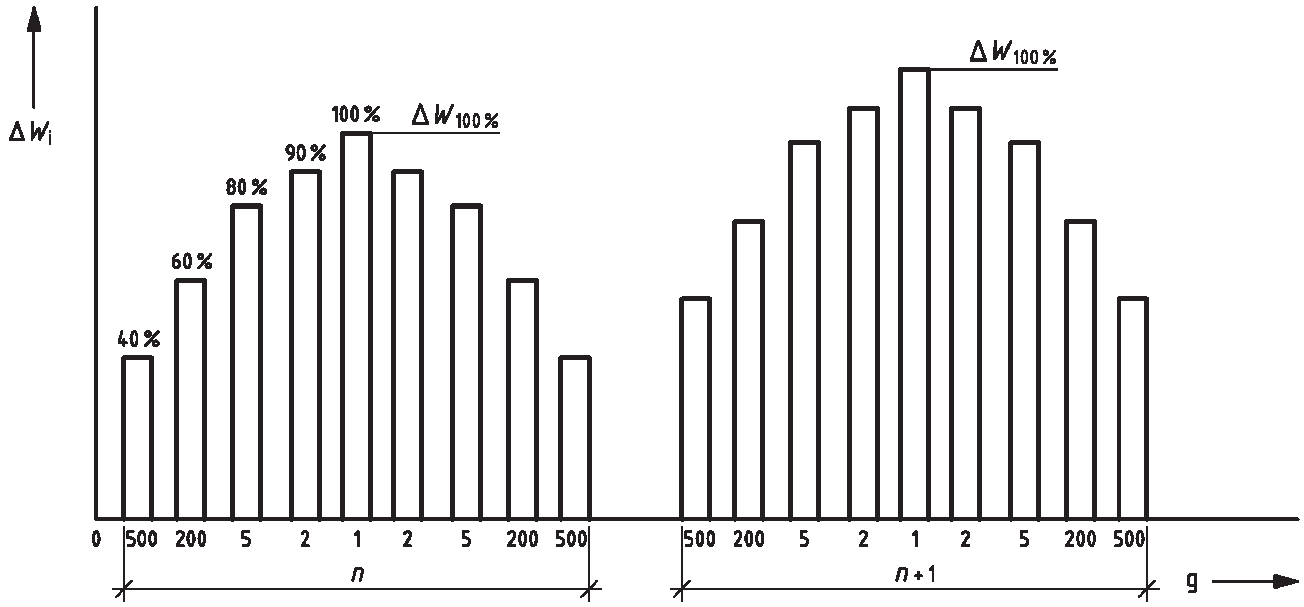
9.3 Installation of the pressure chamber

The pressure chamber shall be fixed symmetrically on the test specimen, see Figure 1.

The pressure chamber shall be clamped on to the flexible sheet of the test specimen to assure an airtight seal over the entire perimeter of the pressure chamber.

9.4 Application of the pressure

The pressure in the chamber shall be applied in such a way that a proportional sequence of peak loads with a given number of gusts is generated according to Figure 4. The pressure in the chamber during each gust shall generate the load/time diagram according to 9.2.



Key

g	number of gusts, specified for each "proportional" peak load in a cycle
n_f	number of cycles until failure
ΔW_i	peak load per fastener, in newtons
$\Delta W_{100\%;n}$	maximum peak load per fastener per cycle (n), with n = 1, 2, 3, …, n_f, in newtons

Figure 4 — Proportional sequence of suction loads

The peak pressure in the chamber during a gust, P_i, shall be according to Equation (4).

$$P_i = 0{,}01 \times i \times P_{100\%;n} \tag{4}$$

$$P_{100\%;n} = 1\,000 \times \frac{\Delta W_{100\%;n}}{A_i} \tag{5}$$

where

A_i is the area of influence of the fastener, in square millimetres (see Figure 1);

i is the proportional part of $P_{100\%;n}$ according to Figure 3, in percent;

n_f is the number of cycles until failure;

$P_{100\%;n}$ is the peak pressure in the pressure chamber during cycle (n), in kilopascals;

$\Delta W_{100\%;n}$ is the peak load per fastener of cycle (n) with n = 1, 2, 3, …, n_f according to Table 1, in newtons.

Table 1 — Peak loads of each cycle

Cycle (n)	$\Delta W_{100\%;n}$ N
1	300
2	300
3	300
4	300
5	400
6	500
7	600
8	700
.	.
.	.
n_f	.
NOTE 1 The peak load is increased in steps of 100 N per fastener until failure of the test specimen.	
NOTE 2 The maximum value of n_f is 22.	

9.5 Registration of test results

The following results shall be registered during and after the test procedure:

a) the environment temperature shall be measured at each cycle change;

b) the behaviour of the test specimen shall be observed during each cycle;

c) record the peak pressure ($P_{100\%;j}$) and number of cycle (j) at which the test specimen fails.

10 Evaluation and expression of results

10.1 Calculation characteristic load

The characteristic load per fastener shall be calculated according to Equation (6).

$$\Delta W_{char} = 0{,}001 \times P_{test} \times A_i \times C_a \times C_d \quad (6)$$

where

A_i is the area of influence of the fastener, in square millimetres (see Figure 1);

C_a is a geometric correction factor according to 10.2;

C_d is a statistical correction factor according to 10.3;

P_{test} is the peak pressure of the cycle preceding the cycle of failure, in kilopascals;

ΔW_{char} is the characteristic load for the resistance to wind uplift per mechanical fastener, in newtons.

10.2 Factor C_a

The factor C_a is the geometric factor allowing for the difference between the deformation of the mechanically fastened sheet in the test and the real deformation of the sheet on a complete roof. The factor C_a depends on the parameters a/b and m/b in accordance to 8.2.

The factor C_a shall be determined from Figure 5 and shall be ≤ 1,0.

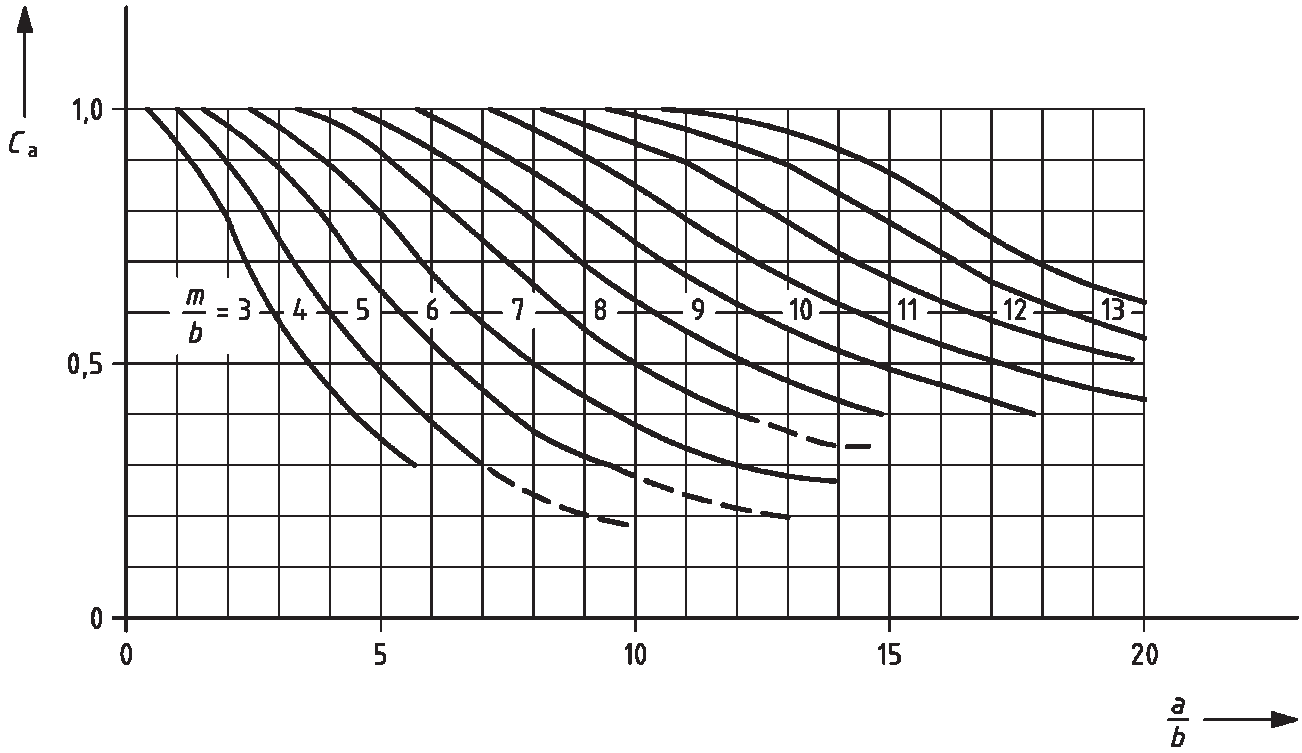


Figure 5 — Determination of factor C_a

10.3 Factor C_d

Factor C_d is a statistical factor allowing for the reduction in the probability of failure of one fastener, due to the reduced number of fasteners in the test system. The value of C_d shall be determined from Table 2.

Table 2 — Factor C_d

α	β	C_d
2	≤ 3	--- *)
	4	0,85
	≥ 5	0,90
3	≤ 2	--- *)
	3	0,90
	4	0,95
	≥ 5	1,0
≥ 4	≤ 2	--- *)
	≥ 3	1,0

where

α is the number of spaces between the rows of fasteners;

β is the number of spaces between the fasteners;

*) layout not allowed.

11 Application rules

11.1 General

The test result obtained with a test specimen at a pitch of (0 ± 2)° or a pitch of (90 ± 2)°, is applicable for mechanically fastened flexible waterproofing sheets for roof waterproofing.

11.2 Substrate

The test result is valid for the same mechanically fastened flexible sheets applied on other types of substrates (including all types of insulation) provided that the characteristic axial loading resistance of the same type of mechanical fastening system in combination with the other substrate is higher than the characteristic axial loading resistance of the mechanical fastening system on the substrate that was used for the test. The axial loading resistance shall be determined according to ETAG 006:2000, Annex D.

NOTE A description of the mechanical fastening system used is a part of the test report.

11.3 Vapour control layer

The test results of a test specimen without a vapour control layer are valid for applications of mechanically fastened sheets in roofing systems with a vapour control layer.

12 Test report

The test report shall include at least the following information:

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a) declared description of the material of the test specimen, including the sampling details, product type, trade name or other means of identification;

b) dimension of the test specimen;

c) number of test specimen;

d) fastening pattern;

e) description of the fasteners (type, dimensions, washer, etc.);

f) description of the jointing technique of the seams;

g) pitch of the test specimen during testing;

h) temperature of the environment at each cycle during the whole test;

i) mode of failure;

j) peak pressure, number of cycle at which the test specimen fails;

k) characteristic load ΔW_{char}, area of influence A_i and correction factors C_a and C_d;

l) date of the tests;

m) date of the last calibration of the test equipment;

n) name of manufacturer and/or supplier of the test material;

o) any other factor that could have influenced the result.

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