SLOVENSKI STANDARD
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Smernice za načrtovanje mehansko pritrjenih strešnih hidroizolacijskih sistemov

Design guideline for mechanically fastened roof waterproofing systems

Richtlinie für die Konstruktion von mechanisch befestigten Dachabdichtungssystemen

Règles de conception des systèmes d'étanchéité de toiture fixés mécaniquement

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Design guideline for mechanically fastened roof waterproofing systems

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Richtlinie für die Konstruktion von mechanisch befestigten Dachabdichtungssystemen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (CEN/TS 17659:2021) has been prepared by Technical Committee CEN/TC 254 “Flexible sheets for waterproofing”, the secretariat of which is held by NEN.

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1 Scope

This document gives guidance for the design of a roof waterproofing system mechanically fastened to the structural deck in relation to wind load resistance.

This document is intended to be used together with EN 16002 and the relevant clauses of EAD-030351-00-0402-2019.

This guideline does not include the seperate fastening requirements of the insulation boards, the securement to upstands, perimeter fastening, flashings or other roof details.

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 1990:2002,[1] *Eurocode — Basis of structural design*

EN 1991-1-4, *Eurocode 1: Actions on structures — Part 1-4: General actions — Wind actions*

EN 16002:2018, *Flexible sheets for waterproofing — Determination of the resistance to wind load of mechanically fastened flexible sheets for roof waterproofing*

EAD-030351-00-0402-2019, *Systems of mechanically fastened flexible roof waterproofing sheets*

EN 13707, *Flexible sheets for waterproofing — Reinforced bitumen sheets for roof waterproofing — Definitions and characteristics*

EN 13956:2012, *Flexible sheets for waterproofing — Plastic and rubber sheets for roof waterproofing — Definitions and characteristics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13707 and EN 13956 and the following apply.

3.1
fastener
object to fasten the fixing element to a structural deck

Note 1 to entry: Fastener can be e.g. a screw, nail, expanding anchor or rivet.

3.2
fastening system
assembly of the fastener and the fixing element intended to secure the waterproofing system to the structural deck

Note 1 to entry: Fastening system can be e.g. a fastener with a:
- metal washer with or without a plastic sleeve,
- plastic washer with or without an integrated sleeve, or
- metal bar/continuous strips with or without a plastic sleeve.

[1] As impacted by EN 1990:2002/A1:2005 and EN 1990:2002/A1:2005/AC:2010.

Note 2 to entry: Whilst primarily intended to secure the waterproofing system against wind uplift forces, the system may contribute to securing intermediate layers such as thermal insulation, air and vapour control layers (AVCL), etc.

3.3
fixing element
component that secures the waterproofing system, in connection with the fastener, to the structural deck

Note 1 to entry: A fixing element is the fastening system without the fastener.

3.4
flexible sheet for waterproofing
factory made waterproofing sheet, which can be rolled up or folded for easy transport to the site

[Source: EN 13956:2012, 3.4, modified —"Roof" omitted in the term.]

3.5
pull-through failure
failure mode between the fixing element and the waterproofing system

Note 1 to entry: The failure mode can vary dependent of type of fixing element, type of flexible sheet for waterproofing as well as the design of the waterproofing system.

3.6
pull-out failure
failure mode in which the fastener pulls out of the structural deck

3.7
pull-over failure
failure mode in which the fastener pulls through the fixing element

Note 1 to entry: This is called "washer pull-through test" in EAD –030351-00-0402-2019.

3.8
roof build-up
total of different layers which forms the roof from the structural deck to the waterproofing system including the fastening system

3.9
structural deck
construction element, e.g. roofing panel or slab, which has to transfer both permanent and variable loads to the other construction parts of the roof or building

3.10
waterproofing system
assembly of one or more layers of flexible sheets for waterproofing in its applied and jointed form, which has certain performance characteristics, to be assessed as a whole

4 Symbols and abbreviations

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

		Unit
c_{pe1}	external pressure coefficient	-
c_{pi}	internal pressure coefficient	-
k_n	coefficient	-
n_f	minimal required number of fasteners per m^2	-
n	number of samples within one roof area	-
n_{min}	minimum number of fasteners per m^2	-
$Q_{wind;d}$	design value of the wind pressure	kN/m^2
q_p	peak velocity pressure	kN/m^2
$R_{d;field\ pull\text{-}out}$	admissible (design) value of axial pull-out load of the fastener in the specific structural deck on site	kN
$R_{d;pull\text{-}out}$	admissible (design) pull-out value of the fastening system in a specific structural deck	kN
$R_{d;pull\text{-}over}$	admissible (design) pull-over value of the fastening system	kN
$R_{k;field\ pull\text{-}out}$	characteristic value of axial pull-out load of the fastener in the specific structural deck on site	kN
$R_{k;pull\text{-}out}$	characteristic pull-out value in a specific structural deck	kN
$R_{k;pull\text{-}over}$	characteristic pull-over value	kN
s	standard deviation	-
ΔW_{adm}	admissible (design) load for the resistance to wind uplift per fastening system	kN
$W_{adm;system}$	admissible (design) load resistance of the waterproofing system per fastener	kN
ΔW_{char}	characteristic load for the resistance to wind uplift	kN
w_e	external wind pressure	kN/m^2
w_i	internal wind pressure	kN/m^2
w_{tot}	characteristic value of the wind pressure	kN/m^2
x_m	mean value of all field pull-out tests	kN
$x_{n;i}$	test result of test i with i is 1 to n	kN
γ_Q	partial (safety) factor for wind load	-
γ_M	material partial factor	-

5 Introduction to design concept

5.1 Introduction

This technical specification intends to give guidance how to use EN 1991-1-4 in practice when designing a roof with a mechanically fastened waterproofing system. This document is intented to be used together with EN 16002 and EAD-030351-00-0402-2019.

5.2 Actions on structures - Eurocode 1

5.2.1 General

Eurocode 1 on actions on structures (abbreviated EN 1991 or, informally, EC 1) describes how to design load-bearing structures. It includes characteristic values for various types of loads and densities for all materials which are likely to be used in construction.

EN 1991-1-4 gives guidance on the determination of natural wind actions for the structural design of building and civil engineering works for each of the loaded areas under consideration. This includes the whole structure or parts of the structure or elements attached to the structure, e.g. components, roofing, cladding units and their fixings.

5.2.2 National annex for EN 1991-1-4

EN 1991-1-4 gives alternative procedures, values and recommendations for classes with notes indicating where national choice may be made. Therefore, the National standard of EN 1991-1-4 should have a National Annex containing National Determined Parameters to be used for the design of buildings in the relevant country.

EN 1991-1-4 is intended to be used in conjunction with EN 1990, the other parts of EN 1991 and EN 1992 series to EN 1999 series for the design of structures.

5.3 Wind load resistance of the roof

Mechanically fastened waterproofing systems are tested according to EN 16002:2018. Fastening systems are tested according to EAD-030351-00-0402-2019. The evaluated result, as described in Clause 7, gives the conditions for the roof resistance and design possibilities with regards to the calculated wind pressure for the roof.

The evaluation of the test results identifies the weakest of the three failure modes:

— pull-through of fixing element;

— pull-out of the fastener;

— pull-over of the fixing element.

The weakest of these three gives the authoritative design value for the system, $W_{adm;system}$.

5.4 Safety factors

When designing a mechnichally attached flexible waterproofing system using the partial coefficient method the total safety is considered using different safety factors for the actions and the materials. The actions are considered by use of the probability and the durability whereas the components are considered by the material characteristics.

6 Wind load - Design value of the wind pressure

6.1 Wind pressure (w_{tot})

EN 1991-1-4 defines the wind pressure per m² for each zone on the roof (e.g. corner-, perimeter- and field zone) from the formula:

$$w_{tot} = w_i + w_e = q_p \left(c_{pe1} - c_{pi} \right) \quad (1)$$

where

w_{tot}	is the characteristic value of the wind pressure, in kN/m²;
w_{e}	is the external wind pressure, in kN/m²;
w_{i}	is the internal wind pressure, in kN/m²;
q_{p}	is the peak velocity pressure according to EN 1991-1-4, in kN/m²;
c_{pe1}	is the external pressure coefficient according to EN 1991-1-4;
c_{pi}	is the internal pressure coefficient according to EN 1991-1-4.

The wind pressures are characteristic values. They are determined from the basic values of wind velocity or the wind velocity pressure. In accordance with EN 1990 the basic values are representative values having annual probabilities of exceedance of 0,02 which is equivalent to a mean return period of 50 years.

6.2 Wind load, $Q_{\mathrm{wind;d}}$

For the calculation of the design value of the wind pressure, $Q_{\mathrm{wind;d}}$, the representative value of the wind pressure, w_{tot} shall be multiplied by the partial (safety) factor for wind load, γ_{Q}. The recommended value for γ_{Q} is 1,5, but different values may be set by national annexes.

$$Q_{wind;d} = w_{tot} \times \gamma_Q \quad (2)$$

where

$Q_{\mathrm{wind;d}}$	is the design value of the wind pressure, in kN/m²;
w_{tot}	is the characteristic value of the wind pressure, according to Formula (1), in kN/m²;
γ_{Q}	is the partial (safety) factor for wind load.

NOTE For flexible waterproofing, several European countries are using reduction factors which could lead to a different safety factor, based on consequence classes (EN 1990, CC) judged on the possible low risk of human injury with installations of flexible waterproofing membranes.

7 Admissible (design) load resistance of the waterproofing system

7.1 General

The characteristic value of the load resistance of the waterproofing system and fastening system should be provided by the membrane or fastener supplier respectively, taking into consideration the following failures:

— pull-through of the fastening system, determined with the *full scale dynamic wind load test* according to EN 16002:2018,

— pull-out of the fastener, determined with the *axial loading* test according to EAD-030351-00-0402-2019, Annex A2.1 with test configuration according to Figure 3 of EAD-030351-00-0402-2019,

— pull-over of the fixing element, determined with the *axial loading* test according to EAD-030351-00-0402-2019, Annex A2.1 with test configuration according to Figure 4 or 5 of EAD-030351-00-0402-2019.

For the calculation of the admissible (design) value, the characteristic value should be divided by the material partial (safety) factor, γ_M. The material partial (safety) factor, γ_M varies for different tests and substrates.

For the determination of the authoritative admissible (design) value for the waterproofing system method 1, 2 and 3 could be used:

— Method 1: roof build-up properties are the same as in the *full scale dynamic wind load test*, see 7.2;

— Method 2: properties of the structural deck, and/or fastener (to be) used in the project differs from the one used in the *full scale dynamic wind load test*, see 7.3;

— Method 3: performance of the structural deck is unknown, see 7.4.

7.2 Method 1 - Full scale dynamic wind load system test

In case the used structural deck, waterproofing system and fastening system in the project is the same as has been used in the full scale dynamic wind load test according to EN 16002:2018, the admissible (design) load resistance of the waterproofing system is equal to Formula (3).

$$W_{adm;system} = \frac{\Delta W_{char}}{\gamma_M} \tag{3}$$

where

$W_{adm;system}$ is the admissible (design) load resistance of the waterproofing system per fastener, in kN;

ΔW_{char} is the characteristic load for the resistance to wind uplift per fastener according to EN 16002, in kN;

γ_M is the material partial factor according to 9.1.