SIST

SLOVENSKI STANDARD
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Železniške naprave - Zgornji ustroj proge - Protihrupne ovire in pripadajoče naprave, ki vplivajo na širjenje zvoka v zraku - Neakustične lastnosti - 2-2. del: Mehanske lastnosti pri dinamičnih obremenitvah zaradi mimo vozečih vlakov - Izračun

Railway applications - Track - Noise barriers and related devices acting on airborne sound propagation - Non-acoustic performance - Part 2-2: Mechanical performance under dynamic loadings caused by passing trains - Calculation method

Bahnanwendungen - Oberbau - Lärmschutzwände und verwandte Vorrichtungen zur Beeinflussung der Luftschallausbreitung - Nicht akustische Eigenschaften - Teil 2-2: Mechanische Eigenschaftsanforderungen unter dynamischen Belastungen infolge Zugverkehr - Berechnungsverfahren

Applications ferroviaires - Voie - Écrans antibruit et dispositifs connexes influant sur la propagation aérienne du son - Performances non acoustiques - Partie 2-2: Tenue mécanique sous charges dynamiques dues à la circulation ferroviaire - Méthode de calcul

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ICS:

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93.100	Gradnja železnic	Construction of railways

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English Version

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European foreword

This document (EN 16727-2-2:2016) has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by November 2016, and conflicting national standards shall be withdrawn at the latest by November 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This European Standard is one of the series EN 16727, *Railway applications — Track — Noise barriers and related devices acting on airborne sound propagation — Non-acoustic performance*, as listed below:

— *Part 1: Mechanical performance under static loadings — Calculation and test methods* [currently at Enquiry stage];

— *Part 2-1: Mechanical performance under dynamic loadings due to passing trains — Resistance to fatigue* [currently at Enquiry stage];

— *Part 2-2: Mechanical performance under dynamic loadings caused by passing trains — Calculation method* [published];

— *Part 3: General safety and environmental requirements* [currently at Enquiry stage].

It should be read in conjunction with:

— EN 1990, *Eurocode — Basis of structural design*;

— EN 1991-2, *Eurocode 1: Actions on structures — Part 2: Traffic loads on bridges*;

— EN 1992 series, *Eurocode 2: Design of concrete structures*;

— EN 1993 series, *Eurocode 3: Design of steel structures*;

— EN 1997 series, *Eurocode 7: Geotechnical design*;

— EN 1999 series, *Eurocode 9: Design of aluminium structures*;

— EN 14067-4, *Railway applications — Aerodynamics — Part 4: Requirements and test procedures for aerodynamics on open track*.

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Introduction

Passing trains generate pressure variations in the shape of air pressure waves which impact on noise barriers installed alongside the track. Noise barriers need to withstand this impact without any part of them becoming detached or displaced in a way that creates a safety hazard for passing trains or people. This European standard presents a calculation method to assess the capacity of noise barriers having a post-and-panel structure with piled foundations to resist this pressure variation including an allowance for dynamic response of the structure.

The air pressure wave generated by a passing train is described in terms of two block loads in EN 1991-2:2003, 6.6.2. For calculating realistic static and dynamic actions on noise barriers, it is necessary to consider also the shape of the air pressure wave and the dynamic effects.

1 Scope

This European standard defines the loading, the relevant load model positions and the internal forces acting on noise barriers, due to the air pressure wave set out in EN 1991-2:2003, 6.6.2. The vertical and horizontal shapes of the air pressure wave and the dynamic effects have been taken into account. The calculation method described in this European standard has been developed for noise barriers having a post-and-panel structure with piled foundations. It can also be used where cladding is attached to a rigid structure. For structures with piled foundations, an empirical formula for determination of the natural frequency is given in Annex A. Annex B contains an example of application of the calculation method for determination of internal forces and moments acting on a mid-post. The design of noise barriers (e.g. to fatigue resistance) is not part of this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1991-2:2003, *Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges*

3 Terms and definitions

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

3.1
noise barrier
noise reducing device, which obstructs the direct transmission of airborne sound emanating from railways and which will typically span between posts and also may overhang the railway

Note 1 to entry: Noise barriers are generally made of acoustic and structural elements (3.3 and 3.4).

3.2
cladding
noise reducing device, which is attached to a wall or other structure and reduces the amount of sound reflected

Note 1 to entry: Claddings are generally made of acoustic and structural elements (3.3 and 3.4).

3.3
acoustic element
element whose primary function is to provide the acoustic performance of the device

3.4
structural element
element whose primary function is to support or hold in place acoustic elements

Note 1 to entry: In some noise barriers the acoustic function and the structural function cannot be clearly separated and attributed to different components.

3.5
added device
added component that influences the acoustic performance of the original noise-reducing device (acting primarily on the diffracted energy)

3.6
load model
simplified mathematical description of a complicated loading, such as the air pressure wave generated by a passing train

3.7
quasi-static load model
load model including dynamic effects of loading

4 Symbols and abbreviations

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

a_g distance of wall system surface from the centreline of the track in m

a spacing to a post or between two posts along track in m

f first natural frequency of the wall system in Hz

h wall height above rail top in m

h_m height between the surface of the ground and the top of the rail

h_u height between the top of the pile and the surface of the ground

L influence length in m

l_m effective influence length for the calculation of a mid-post

M_{max} maximum bending moment in kNm/m

M_{post} bending moment of a post in kNm

q_{1k} loading according to EN 1991-2:2003, 6.6.2, in kN/m² without considering the factor k_2

q_{DS} quasi-static load for the air pressure wave due to a passing train at an elevation z above rail top considering the influence length, wall height and dynamic effects in kN/m²

q_{post} loading for a post in kN/m with reference to post height

s_{DS} horizontal spacing between the two relevant load model positions of the air pressure wave for maximum structural reactions, in m

V_{max} maximum shear force in kN/m

V_{post} shear force of a post in kN

V_{train} train velocity in m/s (design speed)

z elevation above rail top in m, where the quasi-static equivalent load shall be calculated. For elevations $z < 0$ it is assumed that $z = 0$

κ_t relation between natural and applied frequency

φ_{dyn} dynamic factor – considering dynamic effects

φ_H height factor – considering wall height and elevation above rail top

φ_{H1} value of φ_H for the ratio $z/h = 1,0$

φ_L length factor – considering the influence length of the air pressure wave

5 Quasi-static equivalent load model

5.1 Application requirements

The air pressure wave due to a passing train may be determined according to the defined quasi-static equivalent load model presented in 5.3, provided the following criteria are met:

— statically-determined post-and-panel structure;

— post spacing ≤ 7,50 m;

— wall height above rail top ≤ 5,00 m;

— there is negligible torsion of panels;

— there are no additional dynamic actions.

If these requirements are not fulfilled, additional data shall be obtained by numerical methods (e.g. dynamic analysis with an appropriate load model).

5.2 Air pressure wave

The air pressure wave due to a passing train given by the load model in EN 1991-2:2003, 6.6.2, shall be used in combination with the requirements of sub-Clauses 5.3, 5.4, 5.5 and 5.6.

5.3 Quasi-static equivalent load

The quasi-static equivalent load shall be calculated by the following formula:

$$\pm q_{DS} = \varphi_L \cdot \varphi_H \cdot \varphi_{dyn} \cdot q_{1k} \qquad (1)$$

where

$\pm q_{\mathrm{DS}}$ is the quasi-static load for the air pressure wave of a passing train at an elevation z above the rail top considering the influence length, the wall height and the dynamic factor;

φ_{L} is the length factor - considering the influence length of the air pressure wave;

φ_{H} is the height factor - considering wall height and elevation above the rail top;

φ_{dyn} is the dynamic factor - based on consideration of the dynamic response of statically-determined post-and-panel structures;

$q_{1\mathrm{k}}$ is the loading according to EN 1991-2:2003, 6.6.2, without considering the factor k_2. Depending on the shape of the train, $q_{1\mathrm{k}}$ can be multiplied by the factor k_1 as set out in EN 1991–2.

The load q_{DS} shall always be applied, as with the load $q_{1\mathrm{k}}$, in the form of a line load with a horizontal length of 5 m on each side in different directions according to EN 1991-2:2003, 6.6.2, in the relevant load position for calculation of maximum forces and moments. It is important to note that, in contrast to $q_{1\mathrm{k}}$, the load q_{DS} has a variable value related to the elevation above the rail top.

The relevant load model position for $\pm q_{\mathrm{DS}}$ is given in 6.2 to 6.5.

5.4 Length factor

The length factor is presented in Table 1.

For intermediate values of L and h in Table 1, the value of φ_{L} shall be determined on the basis of linear interpolation.

Table 1 — Length factor φ_L

Influence length (m)	**Wall height *h* above rail top** (m)				
L	1	2	3	4	5
0,0	0,97	1,12	1,27	1,42	1,56
2,5	0,95	1,10	1,25	1,40	1,54
5,0	0,92	1,06	1,20	1,35	1,49
7,5	1,02	1,18	1,33	1,49	1,65
10,0	1,21	1,40	1,59	1,78	1,97
12,5	1,44	1,66	1,88	2,11	2,33
15,0	1,69	1,95	2,21	2,47	2,73

For the panels:

Influence length L = span length, in m.

For the posts:

Influence length L = sum of the adjacent panel span lengths parallel to the track, in m.

5.5 Height factor

The height factor is presented in Table 2.

For intermediate values of z/h and h in Table 2, the value of φ_H shall be determined on the basis of linear interpolation.

Table 2 — Height factor φ_H

	Wall height *h* above rail top (m)				
z/*h*	1	2	3	4	5
1,0	0,69	0,65	0,60	0,55	0,51
0,9	0,75	0,71	0,68	0,64	0,60
0,8	0,80	0,77	0,74	0,71	0,68
0,7	0,85	0,83	0,80	0,78	0,76
0,6	0,89	0,87	0,86	0,84	0,82
0,5	0,92	0,91	0,90	0,89	0,88
0,4	0,95	0,94	0,94	0,93	0,92
0,3	0,97	0,97	0,96	0,96	0,96
0,2	0,99	0,99	0,98	0,98	0,98
0,1	1,00	1,00	1,00	1,00	1,00
0,0	1,00	1,00	1,00	1,00	1,00

z = elevation above rail top in m, where the quasi-static equivalent load is calculated. For elevations $z < 0$ it is assumed that $\varphi_H = 1{,}00$.

Alternatively Formula (2) can be used to determine the height factor:

$$\varphi_H = 1 - (1 - \varphi_{H1}) \cdot \left(\frac{z}{h}\right)^2 \qquad (2)$$

where

φ_{H1} is the value of φ_H for the ratio z/h = 1,0.

5.6 Dynamic factor

The dynamic factor φ_{dyn} is presented in Figure 1.

The dynamic factor φ_{dyn} shall be evaluated to two decimal digits.

For $0 \le \kappa_t \le 0{,}5$: $\varphi_{dyn} = 3{,}25$

For $0{,}5 \le \kappa_t \le 1{,}5$: $\varphi_{dyn} = 1{,}10 + 2{,}15 \cdot (0{,}735 \cdot \kappa_t^2 - 2{,}470 \cdot \kappa_t + 2{,}051)$ (3)

For $\kappa_t > 1{,}5$: $\varphi_{dyn} = 1{,}10$