SLOVENSKI STANDARD
SIST EN 1998-2:2006/kprA1:2008
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Evrokod 8 - Projektiranje konstrukcij na potresnih obmoļ jih - 2. del: Mostovi

Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges

Eurocode 8: Auslegung von Bauwerken gegen Erdbeben - Teil 2: Brücken

Eurocode 8: Calcul des structures pour leur résistance aux séismes - Partie 2: Ponts

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ICS:

91.120.25	Zaģļ ita pred potresi in vibracijami	Seismic and vibration protection
93.040	Gradnja mostov	Bridge construction

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Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges

Eurocode 8: Calcul des structures pour leur résistance aux séismes - Partie 2: Ponts

Eurocode 8: Auslegung von Bauwerken gegen Erdbeben - Teil 2: Brücken

This draft amendment is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/TC 250.

This draft amendment A1, if approved, will modify the European Standard EN 1998-2:2005. If this draft becomes an amendment, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for inclusion of this amendment into the relevant national standard without any alteration.

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

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Foreword

This document (EN 1998-2:2005/prA1:2008) has been prepared by Technical Committee CEN/TC 250 "Structural Eurocodes", the secretariat of which is held by BSI.

This document is currently submitted to the Unique Acceptance Procedure.

1) In **1.6.6 Further symbols used in Section 7 and Annexes J, JJ and K of EN 1998-2**

Add:

$d_{m,i}$ maximum total displacement of each isolator unit i

$d_{G,i}$ Offset displacement of isolator i

2) In **7.5.2.4 Variability of properties of the isolator units**

Replace (5) and (6) by:

(5) The nominal design properties of simple low-damping elastomeric bearings in accordance with **7.5.2.3.3(5)** and **(6)**, may be assumed as follows:

– Shear modulus $G_b = \alpha\, G_g$

NOTE: The value of α typically ranges from 1,1 to 1,4. The appropriate value is best determined by testing of the device.

– where G_g is the value of the "apparent conventional shear modulus" in accordance with EN 1337-3:2005;

– Equivalent viscous damping $\xi_{eff} = 0{,}05$

(6) The variability of the design properties of simple low-damping elastomeric bearings, due to ageing and temperature, may be limited to the value of G_b and assumed as follows:

– LBDPs $G_{b,min} = G_b$

– UBDPs depend on the "minimum bearing temperature for seismic design" $T_{min,b}$ (see **J.1(2)**) as follows:

- when $T_{min,b} \geq 0^oC$

  $G_{b,max} = 1{,}2\, G_b$

- when $T_{min,b} < 0^oC$

  the value of $G_{b,max}$ should correspond to $T_{min,b}$.

NOTE: In the absence of relevant test results, the $G_{b,max}$ value for $T_{min,b} < 0^oC$ may be obtained from G_b adjusted regarding temperature and ageing in accordance with the λ_{max} values corresponding to K_p, specified in Tables JJ.1 and JJ.2.

3) In **7.5.4 Fundamental mode spectrum analysis**

Replace (3) by:

(3) This leads to the results shown in Table 7.1 and Figure 7.4.

Table 7.1: Spectral acceleration S_e and design displacement d_{cd}

T_{eff}	S_e	d_{cd}
$T_C \le T_{eff} < T_D$	$2{,}5\,\frac{T_C}{T_{eff}}\,a_g S \eta_{eff}$	$\frac{T_{eff}}{T_C}\,d_C$
$T_D \le T_{eff} \le 4$ s	$2{,}5\,\frac{T_C T_D}{T_{eff}^2}\,a_g S \eta_{eff}$	$\frac{T_D}{T_C}\,d_C$

where:

$$a_g = \gamma_I a_{g,R} \tag{7.7}$$

and

$$d_C = \frac{0{,}625}{\pi^2} a_g S \eta_{eff} T_C^2 \tag{7.8}$$

The value of η_{eff} should be taken from the expression

$$\eta_{eff} = \sqrt{\frac{0{,}10}{0{,}05 + \xi_{eff}}} \ge 0{,}40 \tag{7.9}$$

Maximum shear force

$$V_d = M_d S_e = K_{eff} d_{cd} \tag{7.10}$$

where:

S, T_C and T_D are parameters of the design spectrum depending on the ground type, in accordance with **7.4.1(1)**P and EN 1998-1:2004, **3.2.2.2**;

a_g is the design ground acceleration on type A ground corresponding to the importance category of the bridge;

γ_I is the importance factor of the bridge; and

$a_{g,R}$ is the reference design ground acceleration (corresponding to the reference return period).

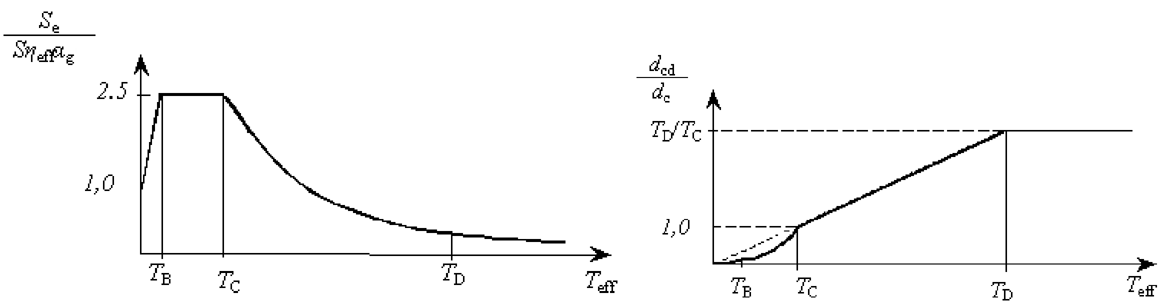


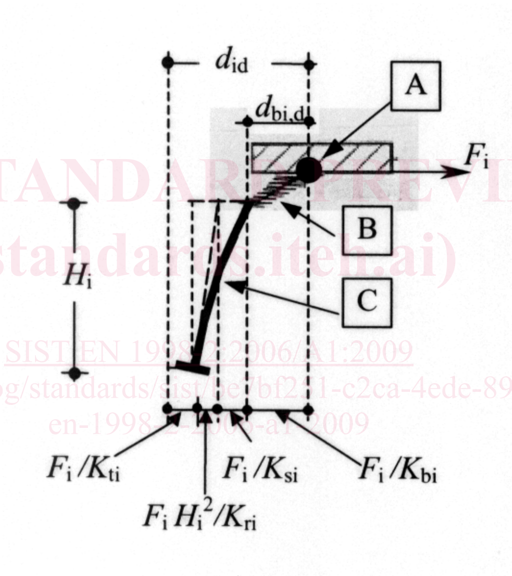
Figure 7.4: Acceleration and displacement spectra

NOTE 1: The elastic response spectrum in EN 1998-1:2004, 3.2.2.2(1)P applies up to periods of 4 s. For values of T_{eff} longer than 4 s the elastic displacement response spectrum in EN 1998-1:2004, Annex A may be used and the elastic acceleration response spectrum may be derived from the elastic displacement response spectrum by inverting expression (3.7) in EN 1998-1:2004. Nonetheless, isolated bridges with T_{eff} > 4 s deserve special attention, due to their inherently low stiffness against any horizontal action.

NOTE 2: For a pier of height H_i with a displacement stiffness K_{si} (kN/m), supported by a foundation with translation stiffness K_{ti} (kN/m), rotation stiffness K_{fi} (kNm/rad), and carrying isolator unit i with effective stiffness K_{bi} (kN/m), the composite stiffness $K_{eff,i}$ is (see Figure 7.5N):

$$\frac{1}{K_{eff,i}} = \frac{1}{K_{bi}} + \frac{1}{K_{ti}} + \frac{1}{K_{si}} + \frac{H_i^2}{K_{fi}} \tag{7.11N}$$

The flexibility of the isolator and its relative displacement $d_{bi} = \frac{F_i}{K_{bi}}$ typically is much larger than the other components of the superstructure displacement. For this reason the effective damping of the system depends only on the sum of dissipated energies of the isolators, ΣE_{Di}, and the relative displacement of the isolator is practically equal to the displacement of the superstructure at this point ($d_{bi}/d_{id} = K_{eff,i}/K_{bi} \cong 1$).



Key

A – Superstructure

B – Isolator *i*

C – Pier *i*

Figure 7.5N: Composite stiffness of pier and isolator *i*

4) In **7.6.2 Isolating system**

Replace (1)P to (5) by:

(1)P The required increased reliability of the isolating system (see **7.3(4)**P) shall be implemented by designing each isolator *i* for increased design displacements $d_{bi,a}$:

$$d_{\mathrm{bi,a}} = \gamma_{\mathrm{IS}} d_{\mathrm{bi,d}} \tag{7.19}$$

where γ_{IS} is an amplification factor that is applied only on the design seismic displacement $d_{\mathrm{bi,d}}$ of each isolator i resulting from one of the procedures specified in **7.5**.

If the spatial variability of the seismic action is accounted for through the simplified method of **3.3(4)**, **(5)**, **(6)** and **(7)**P, the increased design displacements shall be estimated by application of the rule of **3.3(7)**P, where the displacements $d_{\mathrm{bi,d}}$ due the inertia response determined in accordance with one of the methods in **7.5** shall be amplified in accordance with expression (7.19) above, while those corresponding to the spatial variability determined in accordance with **3.3.(5)** and **(6),** need not be amplified.

NOTE The value ascribed to γ_{IS} for use in a country may be defined in its National Annex. The recommended value is $\gamma_{\mathrm{IS}} = 1{,}50$.

(2)P The maximum total displacement of each isolator unit in each direction $d_{\mathrm{m,i}}$ shall be verified from expression (7.19a) by adding to the above increased design seismic displacement, the offset displacement $d_{\mathrm{G,i}}$ potentially induced by:

a) the permanent actions;

b) the long-term deformations (post-tensioning, shrinkage and creep for concrete decks) of the superstructure; and

c) 50% of the thermal action.

$$d_{\mathrm{m,i}} \geq d_{\mathrm{G,i}} + d_{\mathrm{bi,a}} \tag{7.19a}$$

NOTE An additional condition for the displacement capacity $d_{\mathrm{m,i}}$ of the isolators is given in **7.7.1(4)**.

(3)P All components of the isolating system shall be capable of functioning without significant change in isolation properties up to their displacement capacity $d_{\mathrm{m,i}}$ in the relevant direction.

(4)P The design resistance of each load-carrying member of the isolation system, including its anchorage, shall exceed the force acting on the member at the total maximum displacement. It shall also exceed the design force caused by wind loading of the structure in the relevant direction.

NOTE The maximum reaction of hydraulic viscous dampers (see **7.5.2.3.4**) corresponding to the increased displacement $d_{\mathrm{bi,a}}$ may be estimated by multiplying the reaction resulting from the analysis times $\gamma_{\mathrm{IS}}^{\alpha_b/2}$, with α_{b} as defined in **7.5.2.3.4**

(5) Isolator units consisting of simple low-damping elastomeric bearings should be verified for the action effects in **(1)**P to **(4)**P, in accordance with the relevant rules of EN 1337-3:2005 as follows. The maximum total design shear strain in the bearing should be calculated as the sum of

a) the design shear strain due to vertical compression,

b) the shear strain corresponding to the total design horizontal displacement and

c) the shear strain corresponding to the total design angular rotation

of the bearing in the seismic design situation, without multiplication of this sum by an amplification factor. This strain should not exceed the value of $\varepsilon_{\mathrm{u,d}}$ according to relation (2) of

5.3.3 of EN 1337-3:2005. Buckling and sliding stability should be checked according to the relevant rules of 5.3.3.6 of EN 1337-3:2005.

NOTE The value ascribed to the partial factor γ_m in the relation for $\varepsilon_{u,d}$ for use in a country for the calculation of the design resistance of simple low-damping elastomeric bearings in the seismic design situation may be specified in the National Annex of the country. The recommended value is $\gamma_m = 1,00$.

5) In **7.7.1 Lateral restoring capability**

Replace (1)P to (3) by:

(1)P The isolating system shall present self-restoring capability in both principal horizontal directions, to prevent cumulative build-up of displacements. This capability is available when the system has small residual displacements in relation to its displacement capacity d_m.

(2) The requirements in **(1)P** are considered to be satisfied in a direction when the displacement d_0 as defined below meets the following condition in the examined direction:

$$\frac{d_{cd}}{d_0} \geq \delta \tag{7.24}$$

where:

d_{cd} is the design displacement of the isolating system in the examined direction, as defined in **7.2**,

d_0 is the maximum residual displacement for which the isolating system can be in static equilibrium in the considered direction using system properties as defined in this paragraph and in **(5)** below. Thereby no account should be taken of any limitation due to the displacement capacity of the isolators (unlimited capacity). For systems with bilinear behaviour, according to **7.5.2.3.2** or systems that can be approximated as such, d_0 is given as:

$$d_0 = F_0 / K_p \tag{7.25}$$

δ is a numerical value

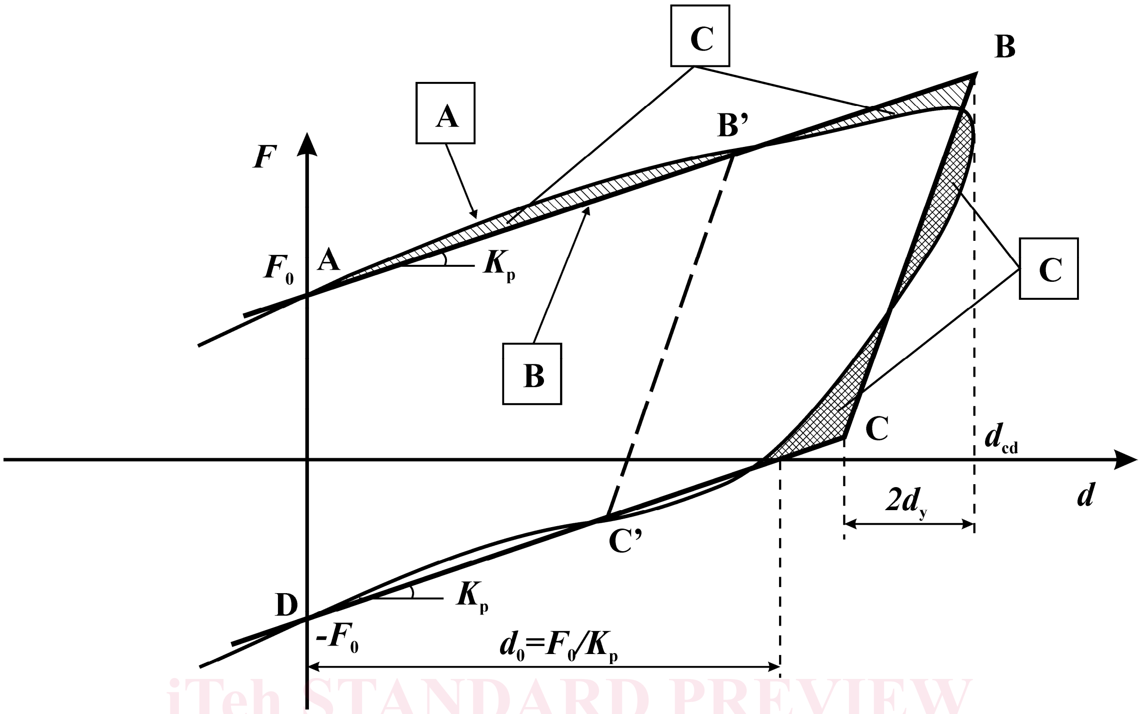
NOTE 1: The value of ratio δ for use in a country may be found in its National Annex. The recommended value is $\delta = 0,50$ (see also Figure 7.8 and **7.7.1(4)** Note 2).

NOTE 2: For systems that are approximated by bilinear hysteretic behaviour (see Figure 7.6N) the properties of the equivalent bilinear system should be determined as follows: The force value at zero displacement F_0 and an estimated value of the design displacement d_{cd} are maintained. The straight lines for the loading branch AB and the unloading branch BC are defined so as to approximate the corresponding branches of the actual loop on an equal area basis.

NOTE 3: For systems with bilinear behaviour according to **7.5.2.3.2,** or systems that can be approximated as such, the displacement $d_0 = F_0/K_p$ depends on properties of the isolating system considered independently from its displacement capacity. Therefore in Figure 7.6N the systems with the loops ABCD and AB'C'D have the same d_0. The value of d_0 is positive when the post-elastic stiffness K_p is positive, negative when K_p is negative, and ∞ when K_p is zero. Systems with negative K_p should not be used.

NOTE 4: For systems of sliding devices with spherical sliding surface (see **7.5.2.3.5(2)**) $d_0 = \mu_d R_b$.

NOTE 5: For systems with hysteretic behaviour that cannot be approximated by a bilinear relationship (see Figure 7.7N) the value of d_0 may be defined from the intersection of the post-elastic branches with the displacement axis. The yield displacement d_y may be assumed equal to zero, for increased reliability.



Key

F – Force

d – Displacement

A – Actual force-displacement relation

B – Approximation by bilinear model (ABCD)

C – Equal areas

Figure 7.6N: Definition of the equivalent bilinear model for the evaluation of restoring capability