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PARAMETRIC CORRELATIONS BETWEEN THE ELASTOMER PHYSICAL AND MECHANICAL PROPERTIES AND THE SEISMIC ELASTOMERIC ISOLATORS PERFORMANCES

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Abstract: *The paper presents the parametric correlations between the elastomer physical and mechanical properties (equivalent elasticity module, tensile strength, compressive deformation degree, etc.), the constructive solution of elastomeric seismic isolators (geometric and dimensional characteristics), and the performance parameters which determine the capacity for use of these devices, within different solutions for the seismic protection of bridges subjected to low seismic actions.*
The aim is to identify and quantify the factors that influence, in a decisive way, the elastomeric seismic performances isolators, so that an analysis method to be established , which allows the evaluation by calculation, with an appropriate degree of accuracy, of the behaviour and the performance characteristics for different constructive types of such products.
Keywords: *elastomeric materials, seismic isolators, assessment methods, performance*

1. INTRODUCTION

The technical regulations which are applicable for the validation of performance of seismic elastomeric isolators used for bridges / viaducts subjected to low seismic actions (EN 15129, EN 1337-3), allow the use of the tests results, tests conducted in order to establish the physical-mechanical properties of the basic constitutive materials (elastomer, steel), aiming the assessment, by calculation, of certain performances of the final product.
In this context, based on the calculation models (parametric correlation) presented in the scientific literature, it can be identified and analyzed the influences of the particular characteristics of constructive solution for anti-seismic devices (corresponding to various particular solutions of seismic isolation). The obtained results will enable the development of a combined assessment methods that will reduce the costs associated implied by the verification and analysis of the capacity for use of such products.

2. SEISMIC ELASTOMERIC ISOLATORS PERFORMANCE CHARACTERISTICS

The seismic elastomeric isolators capacity for use as structural bearing solutions for bridges / viaducts subjected to low seismic actions is determined, according to Regulation (EU) no. 305 / 09.03.2011 (article 3.2), based on the essential characteristics defined in Annex ZA, table ZA.1 of EN 15129 standard, in relation with the level of performance imposed by the functional requirements as defined in the construction structure design.
In the Annex ZA.3 of EN 15129 are stated three methods which can be used by the manufacturer in order to declare the products performance:

1. the presentation of the performance essential characteristics, as specified in the reference document, based on the results of experimental tests specific for the intended use;
2. the presentation of information regarding the constituent materials properties, which are relevant for the essential requirements (safety and durability in use), based on the type 3.2 inspection certificates, issued according the EN 10204 standard provisions;
3. the demonstration of the compliance with the design specifications prepared by the construction structure designer, based on the verification documents as specified by the applicable technical and legal regulations

Where the use conditions for elastomeric seismic isolators are critical, namely whether, following the failure of one individual device, the construction or parts of it exceed the serviceability limit state or the ultimate limit state, as defined by the designer, under certification system 1 assessment (decision 95/467 / EC), for the declaration of product performance, it is mandatory to apply the method 1.
In Table 1, are presented all the necessary elements for the elastomeric seismic isolators selection, in accordance with the specific intended use requirements for structural bearing solutions used on bridges / viaducts subjected to low seismic actions.

Table 1: Requirements for the performance assessment / capacity for use validation

Essential requirement / Assessment elements, Performance parameters	Testing method/ Type of verification	Acceptance criteria (Value / Level / Performance Class)
1. load bearing capacity		
[8.2.1.2.7/ EN15129] **horizontal displacement capacity** (lateral flexibility): **N_{Ed} ($N_{Ed,min}$; $N_{Ed,max}$)** - axial design force (compression/tension) acting on a device subjected to the design seismic action; **d_{max}** - total maximum horizontal displacement of the device due to the actions loading the structure ($d_{max} = \gamma_b \cdot d_{Ed}$; $d_{Ed} = \gamma_x \cdot d_{bd}$; $d_{bd} = T_q \cdot \varepsilon_{q,E}$) [4.3.2.1/ EN1337-3] steel-elastomer **shear adhesion strength**: **N_{sd}** - maximum service vertical load (4.3.3 / EN 1337-3 + 8.2.3.3.2 / EN 15129) **$\varepsilon_{q,max}$** - maximum specific shear deformation ($\varepsilon_{q,max} = v_{xy,d} / T_q$; $v_{xy,d} \equiv d_{max}$) **R_{xa}** - steel-elastomer shear adhesion strength	TEST - 8.2.4.1.5.3 / EN 15129 or annex G / EN1337-3	**C1**: **$N_{Ed,min}$; $N_{Ed,max}$; d_{max} .** $\varepsilon_{q,max} \equiv \varepsilon_{qE} = \frac{d_{max}}{\gamma_b \cdot \gamma_x \cdot T_q} > 200\%$ - the isolator shows no sign of yielding to the end of the test (failure adhesion steel - elastomer, surface cracks or imperfections larger than 2 mm in width or depth, elastomer surface integrity for fixing on the loading plates, wrong position of the reinforcing plates, folds due to the reinforcement plates retention effects - evenly distributed). **C2**: **N_{sd} ; $\varepsilon_{q,max}$.** $\varepsilon_{q,max} \equiv \varepsilon_{qE} = \frac{d_{max}}{\gamma_b \cdot \gamma_x \cdot T_q} \leq 200\%$ - the slope of force-deformation curve (elastic stiffness, **k_e**) should not present a maximum or minimum value up to the specific shear deformation value $\varepsilon_{q,max} = 2$ ($\varepsilon_{q,max} = 200\%$); - to $\varepsilon_{q,max}$, the insulator lateral surface should not present cracks inside the elastomer mass due to the moulding defects or adhesion defects; as appropriate, the failure mode and the value for shear adhesion resistance (R_{xa}) shall be recorded.
[8.2.1.2.8/ EN15129] + [4.3.4 / EN 1337] **compressive stiffness** , Kv **F_{z2}** - maximum design load for the serviceability limit state (SLS); it can be considered $F_{z2} \equiv N_{sd} = 5 \cdot G \cdot A' \cdot S / 1,5$ (4.3.3/EN 1337-3); **F_{z1}** = 30% F_{z2}; $K_v \equiv C_C = \frac{F_{z2} - F_{z1}}{v_{z2} - v_{z1}}$, $E_{cs} = \frac{\sigma_{c2} - \sigma_{c1}}{\varepsilon_{c2} - \varepsilon_{c1}}$; $\varepsilon_c = \frac{v_z}{T_0}$ where: v_{z1} and v_{z2} - related deformations for F_{z1} and F_{z2}; T_0 - the elastomer average thickness, without protective coverage layer on the isolator top and bottom.	TEST - annex H EN 1337-3	- the slope of force-deformation curve (elastic stiffness, **k_e**) must not have a maximum or minimum value up to the to the maximum value of the designed load; - at maximum load, the isolator lateral surface should not present structural imperfections: cracks caused by moulding faults, or adhesion defects; reinforcement plates not aligned laterally or vertically displaced (the folds due to the reinforcement plate retention effect have to be evenly distributed); adherent failure to steel-elastomer interface; - the values for **K_v** or **E_{cs}** determined during the production control tests have to fall within the range of ±30% of the values determined in the initial type testing (ITT).
[8.2.3.4.2 /EN 15129]- the design **total maximum specific deformation** , **$\varepsilon_{t,d}$** $\varepsilon_{t,} = K_L \cdot (\varepsilon_{c,E} + \varepsilon_{q,E} + \varepsilon_{\alpha,})$ **$\varepsilon_{c,E}$** - specific compression deformation; **$\varepsilon_{q,E}$** - specific shear deformation; **$\varepsilon_{\alpha,d}$** - specific angular rotation deformation	CALCULATION - 5.3.3/ EN 1337-3 + 8.2.3.3.2; 8.2.3.3.3/ EN 15129	- the sum of specific deformation ($\varepsilon_{t,d}$) due to the effects of the designed loads should not exceed the maximum ($\varepsilon_{u,d}$): $\varepsilon_{t,d} \leq \varepsilon_{u,d} = 7/\gamma_m$ (γ_m- partial safety factor according to the material) $\varepsilon_{c,E} = \frac{6 \cdot S \cdot N_{Ed,max}}{A_r \cdot E'_c}$; $E'_c = 3 \cdot G(1 + 2 \cdot S^2)$ $\varepsilon_{q,E} = \frac{d_{bd}}{T_q} \leq 1$; $\varepsilon_{\alpha,d} = \frac{((a')^2 \cdot \alpha_{a,d} + (b')^2 \cdot \alpha_{b,d}) \cdot t_i}{2 \sum t_i^3}$ E'c - the longitudinal elasticity modulus corrected value taking into account the elastomer compressibility (annex I / ISO 22762-2).

[8.2.3.4.3/ EN 15129] - **the reinforcing plate thickness** (interior reinforcement) , $\mathbf{t_s}$ $\mathbf{A_r}$ – the effective flat area reduced due to loading effects; $\mathbf{f_y}$ - steel yield strength; $\mathbf{F_{zd}}$ - vertical design load; $\mathbf{t_1}$, $\mathbf{t_2}$ - elastomer thickness on each side of the reinforcing plate; $\mathbf{K_h}$ - calculation coefficient for tensile efforts induced in the reinforcement plates; $\mathbf{K_p}$ - correction factor.	CALCULATION - 5.3.3.5 / EN 1337-3	- the steel reinforcing plate minimum thickness used in an elastomeric isolator have to be $t_s \geq 2$mm. $t_s = \frac{K_p \cdot F_z \cdot (t_1 + t_2) \cdot K_h \cdot \gamma_m}{A_r \cdot f_y}$
[8.2.3.4.4/ EN 15129] **buckling stability** under seismic action ($N_{Ed\,max}$) $\mathbf{P_{cr}}$ - buckling load (isolators with shape factor S > 5) **₵** - buckling coefficient ($\delta = d_{E,d} / a'$, where: a' - reinforcement dimension)	CALCULATION - 8.2.3.4.4 + 8.2.3.3.4 / EN 15129	$N_{Ed,max} < \frac{P_{cr}}{2}$, where: $P_{cr} = \frac{\lambda \cdot G \cdot A_r \cdot a' \cdot S}{T_q}$; $1 - \frac{2 \cdot N_{Ed,max}}{P_{cr}} > 0,7 \cdot \delta$, if: $P_{cr}/2 > N_{Ed\,max} \geq P_{cr}/4$ $\delta \leq 0,7$, if: $N_{Ed\,max} \geq P_{cr}/4$
[8.2.3.4.5/ EN 15129] **roll-over stability** under seismic action ($N_{Ed\,max}$) $\mathbf{k_b}$ - the horizontal shear stiffness corresponding to d_{max} $\mathbf{T_b}$ - total height of the isolator	CALCULATION - 8.2.3.4.5/ EN 15129	$d_{Ed} \leq \frac{1}{\gamma_x} \frac{N_{Ed,min} \cdot a'}{(k_b \cdot T_b + N_{Ed,min})}$ (!) it is verified for the fastening methods used for the anti-seismic devices with buried plate or pins (other fastening methods in comparison with the standard - fixing screws)
[4.3.4 / EN 1337-3] **resistance to repeated compressive stress** ($E_{cs,ob}$) $\mathbf{E_{cs}}$ - the secant compression modulus $E_{cs,ob} \leq E_{cs} (1 + 12\%)$	TEST annex I / EN 1337-3	- E_{cs} determined under static conditions after repeated compressive stress ≡ dynamic fatigue cycle (2,000,000 cycles of compression with σ_z = {min. 7.5 MPa, max. 25 MPa} and frequency f < 3 Hz) + recovery period of 24 hours have to be ≤ initial value of the secant compression modulus increased by 12% ; - surface defects is not allowed: bonding deterioration, cracks in elastomeric mass, others.
[8.2.1.2.10 / EN 15129] - **creep resistance** **(!)** test used in order to verify the design data (optional) N_{Sd} - design load for non seismic conditions (which determines the slow displacements - creep)	TEST - 8.2.4.1.5.4 / EN 15129	- the isolator deformation should not rise excessively, in time, under the supported gravitational loads (N_{Sd}); - the creep percentage determined at specified intervals < 20%, respectively: $\left\| d_{Ed}^{10min} - d_{Ed}^{10^4 min} \right\| \leq 20\% \, d_{Ed}^{10min}$ - no visual signs for structural imperfections or failure on the steel-elastomer bonding interface;
2. shear stiffness (k_b)		
[8.2.1.2.2/ EN 15129**] the specific shear deformation influence** ($\varepsilon_{q,E}$) on shear stiffness $\mathbf{k_b = f(\varepsilon_{q,E}, d_{Ed})}$ (!) the designer/ technical specification shall specify the value d_{Ed} (or % $\varepsilon_{q,E}$) for which k_b is determined	TEST - 8.2.4.1.5.2/ EN 15129	- the value of k_b (or k_2) determined for third loading cycle corresponding to $\varepsilon_{q,E}$ (d_{Ed}) stated by the designer, respectively K_{effb} (secant stiffness) have to be within the range of ± 20% compared to the calculation (design) value / value resulting from ITT; - the reference frequency (0,5 Hz or isolation frequency) and the test frequency are reported
[8.2.1.2.4/EN15129] **operating temperature influence** (T_U / T_L) on shear stiffness (!) test results for the elastomeric material (base material) can be assimilated (!) the designer/ technical specification shall state the specific shear deformation amplitude % $\varepsilon_{q,E}$ (or the d_{Ed} value) for which the operating temperature influence is verified	TEST - 8.2.4.1.5.2/ EN 15129	- the values k_b or k_2 determined for the lower operating temperature T_L should not be different with more than +80% or -20% compared to the values obtained at the reference temperature T=23°C; - the values for k_b or k_2 determined for the upper operating temperature T_U should not be different with more than ±20% compared to the values obtained at the reference temperature T=23°C $[k_b (T_L) - k_b (23°C)] / k_b (23°C) < (+80\% ; -20\%)$ $[k_b (T_U) - k_b (23°C)] / k_b (23°C) < \pm 20\%$

[4.3.1/ EN 1337-3] **shear modulus** (conventional elastic modulus) rated at: nominal temperature, **G_g** / lower temperature, **$G_{g,TS}$** / after aging, **$G_{g,imb}$** $G_g = \frac{\tau_{s2} - \tau_{s1}}{\varepsilon_{qx2} - \varepsilon_{qx1}}$, where: $\tau_s = \frac{F_x}{A}$; $\varepsilon_q = \frac{v_x}{T_q}$; (A - isolator cross section area; T_q – the elastomer average thickness; F_x - shear strength).	TEST - annex F / EN 1337-3	- shear modulus determined within the tests should have the values mentioned by the designer * or the standard value, as follows: ♦ at nominal temperature (23°C): **G_g = 0,9 ï 0,15 Mpa**; respectively G_g* = 0,7 ± 0,10 MPa or G_g* = 1,15 ± 0,20 MPa; ♦ at lower temperature (-25°C) and very low temperature (-40°C): **$G_{g,TS}$ á 3 G_g**; ♦ after aging (test performed at 23°C, 2 days after the accelerated aging): **$G_{g,imb}$ á 3 G_g**. - test piece surface without structural imperfections: porosity, cracks, moulding faults or bonding defects
[8.2.2.1.5/ EN 15129] **resistance to crystallization at low temperature** **(!)** test on elastomeric material for critical conditions of use: zones where the daily average temperature is continuously under -10°C for more than 6 weeks	TEST - 8.2.4.2.5.4 / EN 15129	- the shear stiffness, k_b for the specific shear deformation $\varepsilon_{q,E}$ with amplitudes of 25% and 100%, determined after exposure to low temperature have to be 1,5 times lower than the similar values determined prior to exposure. **(!)** it is verified and recorded if the minimum operating temperature is within the range in which crystallization can occur: NR - at temperature $T_R \leq$ 0°C for $\xi_b > 0{,}06$ (HDRB), or $T_R \leq$ -5°C for $\xi_b \leq 0{,}06$ (LDRB); CR - at temperature $T_R \leq$ 5°C. → the exposure duration and temperature is established.
3. rotation capacity / re-centring capability		
[4.3.5 / EN 1337-3] **static rotation capacity** **~r** - static rotation angle; **M_e** - restoring moment (torque required to rotate the upper / lower surface of the device with a angle of ± 0,003 rad; **M** - resistance to rotation (resistance torque)	TEST - annex J, K / EN 1337-3	- contact area (A_k) and average value for the compressive strain tension (σ_z) should not exceed the specified values; - no structural imperfections are allowed (bonding failure, cracks, etc.) for a rotation angle of α_r =0,025rad; and an eccentricity (L) equal to 1/6 for the minimum plan dimension of the test piece; - restoring moment (M_e) should not exceed the limit defined for specified application (declared by the designer). $M = \left(\frac{F_{z1} - F_{z2}}{4} \cdot L\right)$; $M = G \cdot \frac{\alpha \cdot (a')^5 \cdot (b')}{n \cdot t_i^3 \cdot K_s}$
4. lateral flexibility (horizontal deflection)		
[8.2.1.2.7/ EN15129] **horizontal displacement capacity** (lateral flexibility): **d_{max} ; $N_{Ed\ max}$; $N_{Ed\ min}$ / N_{sd} ; £q,max**	TEST - 8.2.4.1.5.3/ EN 15129 or annex G / EN1337-3	**(!)** if the load capacity has not been evaluated (see pts. 1.)
[8.2.3.4.1/ EN15129] **specific shear deformation**: $\varepsilon_{q,max} = v_{xy,d} / T_q$ ($v_{xy,d} = d_{Ed}$)	CALCULATION - 5.3.3/EN 1337-5	$\varepsilon_{q,max} = \varepsilon_{q,E} \leq 1$ $\varepsilon_{q,max} = d_{Ed}/T_q$; $d_{Ed} = \gamma_x \cdot d_{bd}$
[8.2.3.4.2 /EN 15129] total design **maximum specific deformation**, **£t,d**	CALCULATION - 5.3.3/EN 1337-3 + 8.2.3.3.2; 8.2.3.3.3/ EN 15129	$\varepsilon_{t,d} = K_L \cdot (\varepsilon_{c,E} + \varepsilon_{q,E} + \varepsilon_{\alpha,d}) \leq 7/\gamma_m$ **(!)** if the load capacity has not been evaluated (see pts. 1.)
[4.3.2 / EN 1337-3] **rezistenta la forfecare a aderentei otel-elastomer steel-elastomer shear adhesion strength** nominal temperature (23°C) / after aging (3 days at 70°C).	TEST - annex G / EN 1337-3	- the force-deformation curve slope (elastic stiffness, **k_e**) should not present a maximum or minimum value up to the specific shear deformation $\varepsilon_{q,max} = 2$ ($\varepsilon_{q,max}$ = 200%); - at $\varepsilon_{q,max}$, the lateral surface of the isolator should not present cracks inside the elastomer mass due to moulding faults or adhesion defects; as appropriate, there shall be recorded the failure mode and the value for shear adhesion resistance (R_{xa})
5. durability		
[4.3.6 / EN 1337-3] **ozone resistance exposure duration**: 72 hours; **ozone concentration:** 25 ppsm for natural rubber (NR) / 50 ppsm for chloroprene rubber (CR); **load:** compressive strain tension σ_z = 1,3·G·S; shear force corresponding to $v_x = 0{,}7 \cdot T_q$.	TEST - annex L / EN 1337-3	- without cracks in the rubber due to moulding / manufacturing faults; - no signs of steel-elastomer adherence degradation (presence of prominent / irregular striations or reinforcement plates alignment deviations) visible on the lateral surface of the isolator

[4.4.2 / EN 1337-3**] the elastomer physical and mechanical properties**		**NR** (G=0,9 MPa)	**CR** (G=0,9 MPa)
♦ tensile strength (TS) - ISO 37; ♦ minimum elongation at break (E_b) - ISO37 ♦ hardness - ISO 7619; ♦ residual deformation after compression - ISO 815; ♦ tear resistance (T_s) - ISO 34-1; ♦ aging influence on the mechanical characteristics -ISO 188: - hardness variation - tensile strength variation - variation for elongation at break ♦ ozone resistance - ISO 1431-1 (only for chloroprene – CR)	TEST - according to the method from Table 1 / EN 1337-3 + Table 25 / EN 15129 (pts. 10.3.2)	≥ 16 MPa min. 425 % ≥ 60 ± 5 °Sh A ≤ 30% ≥ 8 kN/m aging conditions: 7 days at 70°C - 5 / +10 IRHD ± 15 % ± 25 % —	≥ 16 MPa min. 425 % ≥ 60 ± 5 °Sh A ≤ 15% ≥ 10 kN/m aging conditions: 3 days at 100°C ± 5 IRHD ± 15 % ± 25 % without cracks

The information contained in the product declaration of performance have a commercial purpose, and can be specified only some of the essential characteristics for the intended use. In the article 6.3c of the Regulation (EU) no. 305 / 09.03.2011 it is stated that it is allowed the declaration of "at least one of the essential characteristics". In this case, it is mandatory to be presented data concerning all the performance parameters associated with the essential characteristic - see Table 1.

3. THE PERFORMANCE CHARACTERISTICS ASSESSMENT, BY CALCULATION

The verification calculation of performance parameters for seismic elastomeric isolators aims to assess the behaviour of a seismic isolation system, corresponding to their fundamental functions: bearing capacity, lateral flexibility, energy dissipation and re-centring capability.
The fulfilment of the performance level imposed by the design / technical specification demonstrates that the seismic elastomeric isolator complies the specific functional requirements and remains operational during the service period.
Below, it is presented an calculation example for the limit functional performances determination for a seismic elastomeric isolator, based on its constructive characteristics and physical and mechanical properties of constituent materials.

3.1. Initial data

Seismic chloroprene type rubber isolator (CR) with rectangular shape, having dimensions 200×300×41mm and the following constructive characteristics: 3 elastomer layers with thickness t_i =8mm, n = 4 steel reinforcing plates S235 (EN10025) with thickness ts = 3mm, elastomeric coating layer on the upper / lower surfaces $t_{ta} = t_{tb}$ = 2,5mm, elastomeric coating layer for lateral surface c = 5mm. The elastomer physical and mechanical properties are: tensile strength TS = 18 MPa, elongation at break E_b = 437%, hardness 62°Sh A, residual deformation after compression 8%, tear resistance T_s = 14 kN/m.

3.2. Bearing capacity (N_{Ed} / $F_{z,d}$; K_V / E_{CS})

The maximum gravitational loads that can be supported on to an individual device, in the designed seismic action safety conditions is determined considering the specific deformation to the allowed compression for the elastomer, with the equation (1), taking into account the conditions imposed for buckling stability and slip resistance. The experimental verification of the bearing capacity and the calculation correlation coefficients defining are realised for performance parameters defined in equation (2).

$$\varepsilon_{c,d}^{max} = \frac{1{,}5 \cdot F_z}{G \cdot A' \cdot S} \; ; \; \varepsilon_c^{max} = \frac{6 \cdot S \cdot N_{E,d}}{A' \cdot E_c} \; ; \; E_c = 3 \cdot G(1 + 2 \cdot S^2) \qquad (1)$$

$$K_v \equiv C_c = \frac{F_{z2} - F_{z1}}{v_{z2} - v_{z1}} ; \quad E_{cs} = \frac{\sigma_{c2} - \sigma_{c1}}{\varepsilon_{c2} - \varepsilon_{c1}}, \text{unde: } \varepsilon_c = \frac{v_z}{T_0} \qquad (2)$$

3.3. Lateral flexibility (d_{Ed} / v_{xy} ; k_b / R_{xy})

The total horizontal displacement for an individual isolator due to the load transmitted to the structure, respectively the isolator shear resistance to the translation movement is calculated using the equation (3).

Experimental verification is performed by calculating the effective modulus of elasticity (4) for a shear stresses load corresponding to the maximum designed displacement. It is verified the condition that the operating load do not exceed the shear resistance value.

$$\varepsilon_{qE} = \frac{v_{Ed}}{T_q};\ d_{Ed} = \gamma_x \cdot d_{db};\ \varepsilon_{qmax} = \frac{v_{xy}}{T_q} \le 1;\ (v_{xy} \approx d_{Ed});\ R_{xy} = \frac{A \cdot G \cdot v_x}{T_q}; \quad (3)$$

$$G_g = \frac{\tau_{s2} - \tau_{s1}}{\varepsilon_{qx2} - \varepsilon_{qx1}}, \text{unde: } \tau_s = \frac{F_x}{A};\ \varepsilon_q = \frac{v_x}{T_q}. \quad (4)$$

3.4. Rotation capability (~R ; Me)

The seismic elastomeric isolators performances to static rotation caused by external load can be a critical requirement for operation, and because of this the specific deformation due to angular rotation, respectively the total vertical deformation (Vc) have to be limited by the appropriate choice of the elastomeric material (5). It is verified the limiting condition of the rotation and the experimental value for the restoring moment (6).

$$Vc = \sum v_z = \sum \frac{F_z \cdot t_i}{A'}\left(\frac{1}{5 \cdot G \cdot S_1^2} + \frac{1}{E_b}\right);\ V_c = b \cdot tg(\alpha_a) = a \cdot tg(\alpha_b);\ M = G \cdot \frac{\alpha \cdot (a'^5 \cdot b')}{n \cdot t_i^3 \cdot Ks}; \quad (5)$$

$$M_e = \left(\frac{F_{z1} - F_{z2}}{4} \cdot L\right) - \frac{(a' \cdot \alpha_a + b' \cdot \alpha_b)}{K_r} \ge 0. \quad (6)$$

3.5. Results

The limit functional characteristics obtained by calculation for the seismic elastomeric isolator mentioned above are: maximum service vertical load N_{sd} = 1145 kN, total maximum horizontal displacement d_{max} = 21 mm, resistance to lateral movement (shear resistance) R_{xy} = 57 kN, maximum angle of rotation α_R = 0,0029 rad. The validation condition for the calculation model is that the correlation coefficient value: C = 1 - |(Xcalc - Xtest) / Xtest| ≥ 90%, where: Xcalc / Xtest - the parameter value obtained by calculation / test.

5. CONCLUSIONS

The selection of the materials and products appropriate for the bearing designed solution of a construction, is one of the basic steps in order to assure the bridges and viaducts safety and durability in use.

The specific performances for a certain type of seismic elastomeric isolator can be assessed by calculation based on the constituent materials properties and taking into account the conditions of use, but in the absence of experimental validation of these data it is not possible to determine or to guarantee the intended use capability for a specific construction work.

In this context, the experimental results obtained following the generally application of the assessment system proposed in this paper will constitute a database that will enable the development of a mathematical model, based on which the behaviour of similar designed products shall be precisely assessed.

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