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Experiences in seismic design of structural bearings and expansion joints for RC bridges according to Eurocodes

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Abstract

The proper seismic design of bridge structural bearings and expansion joints enables avoiding high repair costs after earthquakes. The paper discusses some experiences of the authors in design of bridge bearings and expansion joints according to Eurocodes. Within the scope of the detailed design of several new road overpasses, railway underpasses and railway bridges in the Republic of Macedonia, a special project on design of structural bearings and expansion joints has been realized. Based on the performed analyses, several issues are discussed. First, it has become evident that the geometry and the layout of the bridge structures have an influence on the layout and the fixation of the bearings (i.e., fixed, guided in one direction or bearings movable in all directions). The bridge shape in plane, the number of spans, the alignment disposition, etc. have also affected the adoption of bearing types and dimensions. Finally, the dynamic parameters and seismic behaviour of the bridges have appeared to be crucial in the design of the bearings. The paper also includes a comparison between design of bearings according to the Eurocodes and the Macedonian codes. For the purpose of comparative investigation of different layout solutions for the bearings' fixation, apart from static analyses, dynamic non-linear time-history analyses, using time-history ground acceleration records that correspond to the Eurocode 8 design spectra, have also been performed. From the analyses, the most superior layouts in terms of fixation, position and number of bearings have been obtained for each treated bridge structure. Precious experience has been gained during realization of the project. Since the Eurocodes' design philosophy has already moved toward development of new technologies for bearings, it is inevitable to make changes in the Macedonian practice. This philosophy has brought more freedom to the design process, especially in making decisions in obtaining optimum solutions depending on predominant actions, especially seismic ones.

Key words: structural bearing, elastomer, Eurocodes, EN 1337, bridge structure, thermal action, seismic action, FEM, expansion joints

1 Introduction

The paper is focused on problems in seismic design of structural bearings and expansion joints for RC bridges according to Eurocodes and EN 1337 based on the authors' experiences. Although it mainly deals with seismic actions that have an influence on the bearing design, nondynamic actions, especially thermal and breaking ones, have also been included in the discussion.

The detailed design of several new bridge structures (road overpasses, railway underpasses and railway bridges) along Corridor VIII–eastern section (Kumanovo–Beljakovce section) in the Republic of Macedonia, performed according to the Macedonian codes, has served as a basis for additional design and comparative analysis of structural bearings according to Eurocodes. Since the bearings and expansion joints for the bridges have been adopted based on the result of this additional design, the project appeared to be among the first ones in Macedonia realized by implementation of the Eurocodes and EN 1337. During the design process several issues have been considered. These have mainly been related to the influence of the layout of the bridge structures and the fixation of the bearings discussed in the section 2 of this paper. However, the dynamic parameters and the seismic behaviour of the bridges have appeared to be crucial in the design of the bearings. To evaluate the effect of the bearing fixation, comparative dynamic non-linear time-history analyses have been performed for different layout solutions for the bearings, as discussed in section 3 of the paper. During the realization of the project, it has become clear that the present Macedonian practice that is mainly based on design of movable elastomer bearings disregarding seismic actions should inevitably be abandoned. The Eurocodes' bearing design philosophy offers wider concepts for fixation of bearings - fixed, guided in one direction or bearings movable in all directions, so that new horizons in obtaining optimum solutions for bridge bearings have been opened.

2 Detailed design of six road overpasses, five railway underpasses and one railway bridge

In the paper, the results from the performed analyses and detailed design of structural bearings and expansion joints for the structures along the "Corridor VIII – Eastern Section", Kumanovo – Beljakovce section, Republic of Macedonia, are discussed. The following structures have been analyzed: 1. Road overpasses OP30 (km 3+653), OP31 (km 7+555), OP32 (km 9+060), OP33 (km 12+060), OP34 (km 17+758), OP35 (km 26+582); 2. Railway underpasses UP45 (km 14+951), UP46 (km 16+211), UP47 (km 20+220), UP48 (km 22+631), UP49 (km 24+768) and 3. Railway bridge BR54 (km 24+460). Within the scope of the detailed design the authors of the paper have performed static and seismic analyses of the mentioned bridge structures and have computed the actions according to EN 1990, EN 1991-1-5, EN 1991-2, EN 1992-2, EN 1998-1, and EN

1998-2 (see [1-6]), needed for proportioning of the elastomeric bearings. The design actions on elastomeric bearings, defined as appropriate Ultimate Limit State (ULS) and Serviceability Limit State (SLS) combinations, have been calculated and the so called "Typical bridge bearing schedule" has been prepared according to EN 1337-1, Annex B, Table B.1 and EN 1337-3, Annex E, Table E.1 (see [7, 8, 9]) for all bearings with specified different types of fixation for all structures. It is important to note that, in absence of a National Annex of the Republic of Macedonia to Eurocodes, recommended values of the parameters have been adopted in the analyses, unless otherwise specified in the design text.

2.1 Numerical models for finite glement analysis and applied actions for bearing design

In order to evaluate the design values of the effects of actions E_d on elastomeric bearings for all considered bridge structures, 3D numerical models have been developed for all designed structures. These numerical models have been used for calculation of the natural mode shapes and periods of vibrations, as well as for calculation of the static reactions of each structural bearing, obtained due to all permanent, variable and seismic actions. The analyses have been performed using the Finite Element Method (FEM) based, general purpose software package Tower Radimpex 7.0 [10]. The structures have been appropriately modeled using the generated finite element mesh: Girders and columns have been modeled using beam finite elements. Slabs have been modeled using plate elements and bearings have been modeled using link elements. Since the bearings were the target of the analyses, the structures have been analyzed without consideration of the abutments. For structures with more than one span, middle columns have been included in the models, resulting in optimal design of elastomeric bearings. The 3D design models have appeared especially superior as they allowed appropriate consideration of the horizontal seismic actions.

The elastomeric bearings have been modeled by link elements with stiffness calculated according to specifications given in EN 1337-3 (see [8] and [11]), so that stiffness for all 6 degrees of freedom (three translations and three rotations) has been calculated and prescribed. Also, the boundary conditions of the link elements have been prescribed, according to the designed type of bearing fixation. The shear modulus of the elastomeric bearings has been adopted as Gg = 0,9 MPa (EN 1337-3, 4.3.1.1, see [8]). The bulk modulus Eb has been adopted as Eb = 2000 MPa (1337-3, Eq. (20), Note 1, see [8]). During analysis, the initial values of bearing dimensions and types have been adopted as in the original design. However, in the design process (according to EN 1337-3), the bearing dimensions and types have been changed. The boundary conditions (fixation) have remained unchanged.

The considered action on structures has been classified into three groups (see [1], i.e. EN 1990, 4.1.1): permanent actions (*G*), variable actions (*Q*), and seismic actions (*A*). Permanent actions for railway bridges include self-weight of structure, weight of rails, sleepers and ballast variable actions. For road bridges, permanent actions include self-weight of the reinforced concrete structural elements (girders, slabs, columns), weight due to asphalt, hydro-isolation, RC parapets, noise barriers and/or solid safety barriers on the cantilever parts, RC conduits elements, etc. Variable actions for railway bridges include railway traffic actions (EN1991-2, 6.1., 6.2, 6.3), horizontal forces (centrifugal force (EN 1991-2, 6.5.1), noising force (EN 1991-2, 6.5.2), traction and braking (EN 1991-2, 6.5.3), thermal actions (EN 1991-1-5, 6.1, 6.1.3)), wind actions (EN 1991-1-4, 8.3.2) and actions due to shrinkage and creep of concrete. Variable actions for road bridges include road traffic actions (EN1991-2, 4.3 and 4.4), thermal actions (EN 1991-1-5, 6.1, 6.1.3)), wind actions (EN 1991-1-4, 8.3.2) and actions due to shrinkage and creep of concrete. Characteristic values of actions have been defined according to EN 1990, 4.1.2. Design values of actions have been defined according to EN 1990, 6.3.1 using partial factors g and probability factors y_i. The final adopted *ULS* combinations needed for calculation of the design values E_d of the effects of actions which are necessary for design of bearings for both railway and road bridges have been adopted according to EN 1990, 6.4.3.2, Eq. 6.10b for STR for persistent or transient design situation, and according to EN 1990, 6.4.3.4, Eq 6.12b for seismic design situation. Also, the final *SLS* combinations have been adopted according to EN 1990, 6.5.3a, Eq 6.14a for a characteristic situation and according to EN 1990, 6.5.3a), Eq 6.15b for a frequent situation.

2.2 Applied seismic actions for bearings and expansion joints design according to Eurocodes

Seismic actions have been included in the analyses according to EN 1998-1 and EN1998-2. Mass has been calculated using the characteristic value of permanent loads G_k and a part of the characteristic traffic loads $Q_{k,1}$, using factor $y_{2,1}$ equal to 0.3 for railway bridges and equal to 0.2 for road bridges (EN 1998-2, 4.1.2(4)P):

$$M = G_k + y_{2,1}\ Q_{k,1}. \quad 1)$$

The damping ratio has been adopted to have the value of 0,05 (EN 1998-2, 4.1.3). The behavior factor *q* for bridges with fixed bearings (or partially fixed bearings) according to EN 1998-2, 4.1.6 (10) should be adopted equal to 1,0 if the first horizontal period of vibration T < 0,03 sec, and if T > 0,03 sec, *q* should be adopted to have the value of *q* = 1,5 (EN 1998-2, 4.1.6 (9), (10), (11)). However, in absence of the Macedonian National Annex and having in mind EN 1998-2, 6.6.2.3 (1), (2) and (4), the behavior factor *q* for railway bridges in this study has been adopted to have the value of 1,5 for bridges with middle columns, and value between 1,0 to 1,5 for bridges with one span. The behavior factor *q* for all road bridges with flexible elastomeric bearings (free at all supports) has been adopted equal to 1,0 (EN 1998-2, 4.1.6 (11P), EN 1998-2, 6.6.2.3 (1) c. and (4),EN 1998-2, 7.4.1 (1)P). A multi-mode spectrum seismic analysis has been carried out for all cases. The design spectrum Type 1 for elastic analysis in both horizontal directions has been used (EN 1998-1, 3.2.2.5) for M > 5,5 (EN 1998-1, 3.2.2.2 (2)P, Table 3.2 and Figure 3.2). Class of soil B has been adopted for all analyses, according to the map of soils of the Republic of Macedonia and Eurocode 8 classification. The design ground acceleration has been adopted as $ag = g_I\, a_{gR}$ (EN 1998-1, 3.2.2.2), where importance class factor g_I has been adopted equal to 1,4 for railway bridges and 1,0 for road bridges (EN 1998-2, 2.1 (6)). a_{gR} is the peak ground acceleration (PGA) of the site for a return period of 475 years. As to the choice of PGA, in absence of a map and Macedonian National Annex, an approximate map of PGA for the Republic of Macedonia for a return period of 475 years from one research has been used. Considering the site where the structures are to be built, for all analyses the value of a_{gR} = 0.20g has been adopted. This value also correlates with the positive technical regulative which is in force in Republic of Macedonia (i.e., Regulative 1986, see [11]). According to EN 1998-2 4.1.7 (3)P the effects of the vertical seismic component on bearings in the upward direction has also been considered in the analyses.

2.3 Design solutions for bearings

The final adopted bearing dimensions are shown comparatively in Table 1 for design performed according to Regulative 1986 (see [11]) and Eurocodes (see [1-9]). It should be noted that, for the underpass structures UP45, UP48 and UP49 and the bridge structure BR54 the horizontal seismic actions on bearings computed according to Regulative 1986 were comparatively low compared to those computed according to Eurocodes. That was the reason why Regulative 1986 design was done with no complications regarding the bearing fixation elements that sustain horizontal forces, unlike the Eurocode design where special measures (installation of steel plates) had to be undertaken because of the much higher value of the seismic actions (see the discussion about the difference in seismic actions when using both codes in the subsequent section 2.3). So, Table 1 shows comparatively only the designed dimensions of the rubber, without additional steel plates and bolts needed in the Eurocode design.
For bridge BR54 (see the model in Figure 1), the bearings based on Eurocode design have been adopted of all types of fixities: fixed bearings type B with lower and upper steel plates; guided bearing in longitudinal direction, type D with upper vulcanized PTFE, upper sliding plate with welded stainless steel sheet and lower steel plate; guided bearing in transverse direction, type D with upper vulcanized PTFE, upper sliding plate with welded stainless steel sheet and lower steel plate; and free bearings type C with internal steel plates. The layout of the designed bearings for this bridge is shown in Figure 2, denoted as “layout 1”.

Table 1. Comparison between bearing dimensions designed according to the Macedonian code and Eurocode

Bridge structure	Bearing dimensions [mm]				
	Regulative 1986	Eurocodes (only rubber dimensions)			
	All types	Fixed	Guided x-x	Guided y-y	Free
BR54	NB 300/500/63	250/400/63	200/500/79.5	250/500/79.5	500/400/177
OP30	NB 150/200/28	/	/	/	350/450/132
OP31	NB 150/200/28	/	/	/	350/450/132
OP32	NB 150/200/28	/	/	/	350/450/132
OP34	NB 150/200/28	/	/	/	350/450/116
UP45	NB 200/300/41	180/200/35	190/250/25.5	150/250/25.5	150/250/49
UP48	NB 200/300/41	180/200/35	190/250/25.5	150/250/25.5	150/250/49
UP49	NB 200/300/41	150/250/35	150/350/32.5	150/300/25.5	150/250/56

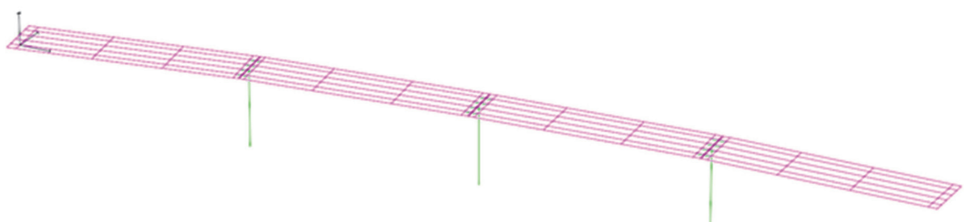

Figure 1. Model of the four-span curved bridge BR54, using the FELISA/3M software package

On the other hand, the overpass structures OP30, OP31, OP32 and OP34 have been designed with free (moveable in both directions) neoprene elastomeric bearings type C. As to the displacement requirements this fixity layout did not result in high values of horizontal displacements in Regulative 1986 design, however it caused problems in Eurocode design because of much higher level of seismic actions. So, the bearings have been designed to have higher dimensions that has resulted in low level of contact stresses, namely less than 3 N/mm^2 (see [8], EN 1337-3, section 5.3.3.6, eq. (16)). Finally, the problem was solved using special thixotropic epoxy adhesive for gluing the steel plates to concrete (with adhesive strength > 4 N/mm^2) on both surfaces in order to avoid separation and/or slippage of the bearings.

2.4 Design solutions for expansion Joints

The expansion joints have been dimensioned according to the obtained horizontal design displacements dE_d in *longitudinal direction* of the structures, using the following two basic combinations:

- Ultimate Limit States (ULS) - Seismic combination:

$$dE_d = 1{,}0 \cdot dE_G \pm 0{,}4 \cdot dE_{Sx} \pm 0{,}5 \cdot dE_T \tag{2}$$

- Serviceability Limit States (SLS), Characteristic combination:

$$dE_d = dE_G + dE_{Qrt} \pm dE_{Htb} \pm 0{,}6 \cdot dE_T + 0{,}6 \cdot dE_{Qsh} \tag{3}$$

In the combinations dE_G denotes displacements due to all permanent actions as self-weight of the reinforced concrete structural elements (girders, slabs, columns), asphalt and isolation in road bridges, the RC parapets, noise barriers and/or solid safety barriers on the cantilever parts, the RC conduits elements, etc. Horizontal displacements due to variable actions are denoted as follows: dE_{Qrt} denotes the horizontal displacements due to vertical road traffic for road bridges, dE_{Htb} denotes horizontal traction and braking displacements; dE_T denotes thermal displacements, dE_{Qsh} denotes concrete creep and shrinkage displacements, and dE_{Sx} denotes seismic displacement. Note that the ULS combination 1 is adopted according to clauses and recommended values in EN 1998-2:2005, Eurocode 8 – Design of structures for earthquake resistance – Part 2: Bridges, 2.3.6.3 (5), Note 1. According to the clause, the adopted values of design displacements will provide normal work of the expansion joints with no damage during the serviceability period, including medium intensity earthquakes that are expected to occur during the serviceability life of the structures (that is the meaning of the coefficient 0.4 for earthquake displacement in the above ULS combination). According to above mentioned clause in Eurocode, for maximum intensity expected earthquakes (with return period of 475 years), the expansion joints are allowed to suffer damage. However, this damage mechanism would provide energy dissipation that will increase the ductility, preventing global collapse of the structure (superstructure falling off). The transverse displacements due to seismic motion have also been reported in order to design the clearance between the girders and side parapet walls in transverse direction on the abutment supports.

2.5 Discussion about differences in design according to Macedonian codes and Eurocodes

The apparently considerable difference between Eurocode design and design of bearings according to the Macedonian code, i.e., Regulative 1986 has arisen as a result of several factors: 1. Difference in the philosophies of actions on structures, especially treatment of thermal ones; 2. Different definition of calculation of mass contributing to seismic actions, i.e., Eurocodes include the contribution of traffic actions while Macedonian codes do not; 3. Difference in ductility factors, i.e. reduction factors of seismic action, which are lower in Eurocode; 4. Much higher value of braking force in Eurocode; 5. Remnants of old practice in Republic of Macedonia including very often neglect of the seismic forces in design of bearings, etc.

As to the first issue, i.e., differences in philosophies of actions, in Regulative 1986, thermal actions are treated as "additional" forces that are never combined with the seismic ones. However, according to Eurocode, thermal actions should be combined with seismic actions (see [6], i.e., EN 1998-2-2005, 5.5. (2)P). Also, the elastic seismic value of displacements (see [6], i.e., EN 1998-2-2005, 2.3.6.3) should be enlarged by the behavior factor *q* (see [6], i.e., EN 1998-2-2005, 2.3.6.1 (6)P, (7) and (8)P). In such a way, the obtained design displacements and forces of bearings are much higher than those treated according to the Macedonian code.
Further, unlike Regulative 1986, according to the Eurocodes, the mass contribution due to traffic should be considered in calculation of the total mass for dynamic analysis with 20 % for road bridges and with 30 % for railway bridges (see [6], i.e., EN 1998-2-2005, 4.1.2 (4)P). This results in greater mass and bigger seismic actions applied to structures when using Eurocodes.
Ductility in Regulative 1986 (see [11], article 23, Table 5) is taken to have the value of 4.0 for "Z1" design action and 5.0 for "Z2" design action, including a special reduction factor for the total seismic force of 0.6. If we consider the relation between seismic intensity and design peak acceleration ([11], article 20, Table 2), the total seismic reduction factor will range between the values of 3.33 and 4.16. However, according to Eurocode (see [6], i.e., EN 1998-2-2005, all stipulations in section 4.1.6 including Table 4.1), reduction factor (called in Eurocode "behavior factor") for the analyzed bridges should be 1.0 for bridges with all movable elastomeric bearings and with maximum value of 1.5 for bridges with different fixation layouts. This results in a considerable difference of calculated seismic force which could be 2.22 to 4.16 times bigger when implementing the Eurocodes, compared to the Regulative 1986. In addition, given that seismic actions used to be often neglected for smaller structures and having in mind the lower values of braking forces in the Macedonian code, the significance of bearing design was usually underestimated in practice, resulting in poor solutions. As a result, considerable damage to bearings of bridge structures along Macedonian roads and railway lines has been observed due to serviceability actions let alone seismic events.
The National Annex to the Eurocodes was recently adopted in the Republic of Macedonia (September 9, 2020). However, despite many deficiencies in the Macedonian seismic codes [11], if properly implemented with efficiently defined bearing layout, they could often result in an acceptable design level. On the other hand, the Eurocodes could seem very rigorous and their direct implementation could cause many problems to designers. Hence, clever adoption of parameters in the National Annex in its next version should be an imperative in order to overcome these difficulties and inconsistencies.

3 Comparative dynamic non-linear analyses of BR54 railway Bridge structure

For the final design, the bearings for all treated structures have been analyzed and proportioned according to Eurocodes and EN 1337, as discussed in the preceding chapter. However, due to deadline restrictions, during the design phase, it was not possible to perform any parametric optimization of the bearings related to their layout considering all the influencing parameters. In the post-design activities, we decided to investigate the efficiency of the optimization process that could lead the design phase, using a model of the bridge structure BR54 (Figure 1) generated in FELISA/3M software system (see [12]). Namely, as discussed in the introduction, the idea was to investigate the influence of the fixation (i.e., the boundary conditions) of the bearings on the seismic behavior of the bridge using five different fixation bearing layouts. The first four layouts are given in Figure 2, while the fifth one that is not shown in the figure, is defined with all eight bearings free in both directions, longitudinal (L) and transverse (T). "Layout 1" represents the actual design solution. Time-history analyses have been performed using original El-Centro ground acceleration records in x and y directions so that, for both directions, 0.2g has been prescribed for PGA. These acceleration records fall approximately into the design spectrum Type 1, as used in the design.

The first three layouts of bearing fixation practically simulated a situation of a simple beam with a free support on the left side and a fixed support of the right side for all spans. The first period of vibration for all three cases was 0.4367 sec. with the first mode shape directed longitudinally in respect to the bridge. Consequently, this resulted in very similar results for all three layouts as to the obtained internal bearing forces and displacements due to seismic actions (see Table 2 for "Layout 3", span 2,). In the table, the fixed bearings are denoted by "F". Also, letters "T" and "L" denote the free moveable directions of the bearings. From the table, it can be seen that the maximum internal horizontal force due to seismic actions in the fixed bearings riches the value of 762 kN in longitudinal direction and 409 kN in transverse direction. On the other hand, the maximum obtained horizontal displacements in the bearings in the case of all three layouts are about 18.2 mm in longitudinal direction (obtained in the first span, not presented here) and 0 in transverse direction.

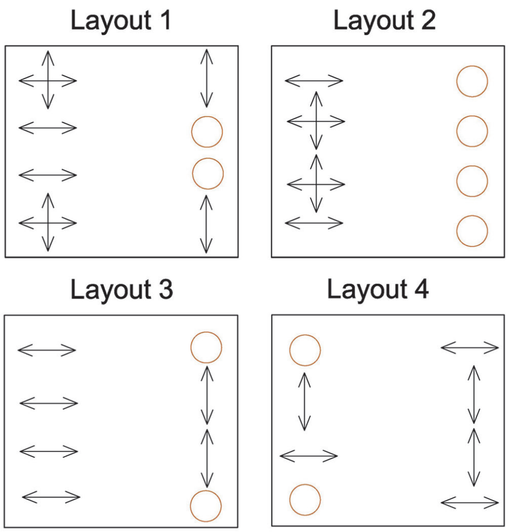

Figure 2. The analyzed bearing layouts. Note that the fifth one is defined with all eight bearings that are movable in both directions (not presented in the figure)

Table 2. Internal bearing forces and displacements for span 2, Layout 3

Bearing no.	**Force** [kN]	**Displacement** [mm]	**Bearing no.**	**Force** [kN]	**Displacement** [mm]	**Direction**
12 L	3	2.5	16 F	687	0	Longitudinal
	243	0		409	0	Transverse
11 L	3	2.5	15 T	687	0	Longitudinal
	210	0		0	0	Transverse
10 L	3	2.5	14 T	762	0	Longitudinal
	189	0		0	0	Transverse
9 L	3	2.5	13 F	682	0	Longitudinal
	127	0		393	0	Transverse

Layout 4 of bearing fixation partially restricted the motion in both directions, resulting in stiffer response, i.e., in the first period of vibration, with a value of 0.2682 sec in longitudinal direction. The maximum developed displacements were 0.7 mm in longitudinal direction and 0 mm in transverse direction. The shift of the period of vibration in stiffer regions of the design spectrum (from 0.4367 sec. to 0.2682 sec.) resulted in much higher induced seismic forces in the bearings. Namely, the internal horizontal force due to seismic actions in guided bearings in transverse direction for span 4 reached a high value of 2338 kN in longitudinal direction. Probably this bearing layout will not behave well under thermal actions, too. Finally, layout 5 has been proposed just to simulate the limit case opposite to the previous one (layout 4) where all bearings are designed free in both directions. As expected, the induced horizontal forces were very low (the maximum values were 43 kN in longitudinal and 85 kN in transverse direction), while on the other hand, the obtained horizontal displacements for span 2 were very high (58,4 mm in longitudinal and 206.6 mm in transverse direction). The obtained first period of vibration of 1.61 sec. resulted in low seismic forces in the bearings for span 1. Unlike the previous case, this layout will not have problems with thermal actions, however, the braking action will be certainly critical, resulting in high displacements like those obtained due to seismic actions.

4 Conclusions

From the above discussion, it is obvious that bearings, as important parts of bridge structures, also deserve special attention and proper seismic design. The conclusions from the investigations can be summarized as follows.

Within the scope of the detailed design of several bridge structures along Kumanovo–Beljakovce section, a special project on design of structural bearings has been realized, being one of the first projects realized by implementation of the Eurocodes and EN 1337 in Macedonia. The gained results and experiences from the project have emphasized the differences between national and Eurocodes' design philosophies. Namely, the structural bearings have been designed according to both codes whereat a considerable difference in the adopted bearing dimensions has been obtained between the two design solutions. From the performed design, several parameters have appeared to be responsible for the differences, as discussed in the paper. Especially, the difference in the computed level of seismic actions according to both codes was one of the most crucial parameters. Further, in order to discuss the influence of the bearing fixation layout on the seismic response of bridge structures, dynamic non-linear time-history analyses have been performed for five different layouts. The fourth layout represented the stiffest case, while the fifth layout represented the most flexible case. Layouts 1, 2 and 3 have been investigated as more realistic options in practice, defined between the two limit cases. The investigation has shown that the period shifting due to change of bearing fixation results in different overall seismic behavior of the bridge structures and es-

pecially different behavior of the bearings. In practice, this means that one should seek an optimal layout solution that will lead to optimal balance between induced bearing horizontal forces and horizontal displacements due to seismic actions.
This research is expected to have an impact on the decisions within the frames of the activities for estimation of the National Annex parameters governing the problems of seismic design of bearings. These have not yet been specified and standardized in our country.

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