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DESIGNING OF SUPPORT ZONES OF CONCRETE BRIDGES TO WITHSTAND ACTION OF STATIC AND DYNAMIC LOAD

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Abstract. *In the paper are presented some of the acquired experiences in designing and construction of bridge structures in several countries, with a special attention to the analysis of support zones and expansion joints behavior of a number of road bridges. During destruction or damage of bridges, there is a small probability, but still there, that the human lives might be endangered (Kobe, Japan 17th January 1995); what is likely, however, is that it will be very difficult to help the injured in the region. Considering that the characteristics of removal of supports has a great influence on the behavior of the entire bridge structure, the design of support joints and connections must be paid due attention. In the recent decades, efforts are made to enhance research of all engineering structure, and thus the bridge structures and their weak points.*

Key words: *bridges, bearings, expansion devices, design.*

1. INTRODUCTION

Bridges and viaducts, as traffic structures, whose cost in some cases amounts to 30% of the total price of the traffic rout, require stability and safety both in regular exploitation, and during the natural disasters and accidents, such as soil vibration during earthquakes. Bridges must not be designed only as static and dynamic structural tasks, without acknowledging that bridges are not only structures, but that bridges contain structures. Accordingly, bearings and joints are parts of bridge structures. Regarding that these structures can absorb a great deal of kinetic energy and that their response mostly depends on their isolation and absorption capacity, we can consider them relatively stable.

Very often the favorably chosen coefficient of damping influences the total absorption of energy. An adequately chosen damping coefficient remarkably well reflects the actual status of stress and strain within range of elastic behavior for the constant rigidity of the structure and the constant damping capacity, and most often it is proportional to the velocity.

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However, for the area of post-elastic behavior, which is expected at strong seismic shocks, the theory of linear viscous damping does not yield the realistic values. The studies done in Japan and China [1] [11] [12] related to the bridge damage occurring during earthquakes and the similar studies from India and the USA indicate that all the parts of a bridge are liable to damage at intensities of earthquakes of VII degree of Mercalli scale and above. For this reason, bridge as a whole and each of its parts ought to be designed for the service and inertial actions occurring during the expected soil movement during earthquakes. The specific property of bridges, as opposed to other structures, is that their integral parts have varying rigidity and damping of various characteristics. For better understanding of influences on bridges and for finding the appropriate design criteria, it is necessary to study the damage on the bridge structures and to determine the main causes of these structures. The most characteristic damage and destruction of bridge structures occurred during the *Fukui* earthquake in Japan 1948 which affected 30 bridges, of which 25 were demolished in the earthquake. During the *Tangehan* earthquake which occurred in 1976 in China, around 60% of road bridges and 40% of railway bridges sustained significant damage in the region. A drastic example of damage to the road bridges is the *San Fernando* earthquake of 1971 in the USA, where in a relatively small area 42 bridges sustained heavy damage, while five of them completely collapsed.

2. Fundamental Principles of Supports and Joints Design

Depending on the type of bridge structure, various aspects of behavior deserve special attention. For instance, the bridges with simply supported beams are prone to failure due the loss-damage of the support, except in the cases when the appropriate details have been very carefully designed. Relative displacements between certain supports, that is, size of joints, can amount to several centimeters and even several tens of centimeters. The maximum movement of the soil during the *El Centro* earthquake (1940) was 21 cm, and the displacement of low-damped systems with a large period can be 1,5 times higher than the maximum soil movement. In the aseismic design of bridges, depending on the location and type of structure, the following types of damage should be taken into account: 1. Service (static and dynamic) load, 2. Soil pressure, 3. Hydraulic pressure, 4. Thrust or lift, 5. Effects of temperature changes, 6. Effects of contraction and creeping of concrete 7. Seismic influences; 8. Effects of consolidation and settlement of the soil, 9. Effects of expansion joints and friction in the supports and 10. Other loads. Combination of various loads depends on the requirements of the corresponding regulations, according to the type of the bridge being considered. [1].

Therefore, civil engineering, particularly the aseismic, both in the country whose entire territory is in the seismically active are, and in the world, is presented by the series of contradictions and oppositions requiring finding out a compromise, provided that the compromise is not at the expense of the safety of the people. It is held that it is not crucial what seismic forces should be taken into account when designing, but that the structures should be resilient, and this requires a well conceived structure and good construction of details, the most important of them being the supports and expansion devices. The first author, in his doctoral dissertation [1] designed a new bearing for the bridge structure, with elements for seismic isolation and absorption of seismic energy. In order to determine strength, damping, yield and failure mechanism and loss of accumulated hysteresis energy, tests of the model to a quasi-static load in cycles until failure have been performed. Model of the mentioned fragment of the bearings was in 1:2 scale. Survival of the structural system must not be endangered, i.e. the structure must retain its integrity. The structure must be strongly and reliably joined into a whole, and it is achieved by designing of special elements responsible for unison behavior of the structure. In designing of the structure, it is necessary to provide for their functionality, cost-efficiency and safety in all possible constellations of the load, though absolute safety cannot be achieved in any structure. In order to have the probability of failure equals zero, there must be an acceptable seismic risk of this type of structures.

3. Supports and Expansion Devices

In prefabricated bridges with multiple spans and high columns, over which are lain the pre-stressed beams in the system of freely supported latticework of individual fields, as are increasingly constructed recently on contemporary highways, the most common damage is either damage of or falling out of beams from the bearings, as the earthquake action is transmitted from the substructure to the superstructure through the bearings, and during the service load from the superstructure to the substructure. Damage of the substructure and superstructure could be avoided by the adequate designing of the bearings (Fig.1). A significant factor at this is, for example, reduction of seismic forces in the superstructure of the bridge, which would consequentially reduce the forces acting on the substructure, and this would facilitate a more cost-effective designing.

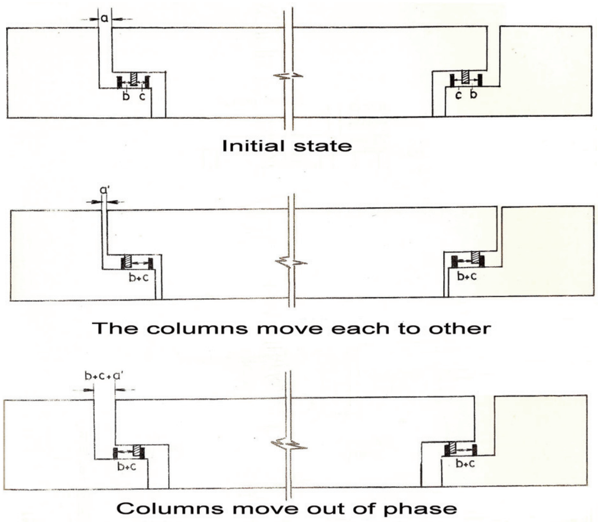

Fig. 1 Displacement of the medium beam in respect to the supporting zones

Considering the importance of the supporting of the superstructure for the magnitude of displacement and redistribution of forces on the substructure, as it has already been said, a new bearing has been designed with the elements for seismic isolation and absorption of seismic energy, whose dynamic model can be represented by the system with two degrees of freedom. (Fig. 2) [2].

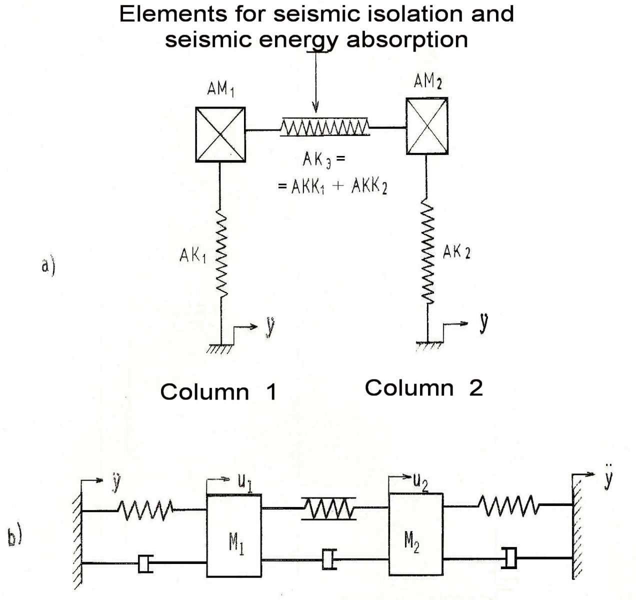

Fig. 2 Dynamic model of the system with two degrees of freedom

The differential equations of the movement of the system with two degrees of freedom, exposed to arbitrary acceleration of soil can be presented in the following matrix form (1):

$$\begin{bmatrix} M_1 & 0 \\ 0 & M_2 \end{bmatrix}\begin{Bmatrix} \ddot{z}_1 \\ \ddot{z}_2 \end{Bmatrix}+\begin{bmatrix} K_1+K_3 & -K_3 \\ -K_3 & K_2+K_3 \end{bmatrix}\begin{Bmatrix} z_1 \\ z_2 \end{Bmatrix}+\begin{bmatrix} 2\omega_1\beta_1 M_1 & 0 \\ 0 & 2\omega_2\beta_2 M_2 \end{bmatrix}\begin{Bmatrix} \dot{z}_1 \\ \dot{z}_2 \end{Bmatrix}=\begin{Bmatrix} -M_1\ddot{y}_1 \\ -M_2\ddot{y}_2 \end{Bmatrix} \tag{1}$$

Where:

$$z_1 = u_1 - y,\ \dot{z}_1 = \dot{u}_1 - \dot{y}\ ,\ \ddot{z}_1 = \ddot{u}_1 - \ddot{y}$$

$$z_2 = u_2 - y,\ \dot{z}_2 = \dot{u}_2 - \dot{y}\ ,\ \ddot{z}_2 = \ddot{u}_2 - \ddot{y} \tag{2}$$

ω_1 , ω_2 – circular frequencies
β_1 , β_2 - damping factors
M_1 , M_2 - generalized masses
K_1, K_2 - generalized rigidity
K_3 - rigidity of the element for seismic isolation and absorption of seismic energy.

Regarding that the rigidity of the elements K_3 non-linearly changes in the function of displacement, the following non-linear differential equations are obtained:

$$z_1 + \left(\frac{K_1}{M_1} + \frac{K_3}{M_1} \right) z_1 - \frac{K_3}{M_1} z_2 + 2\omega_1 \beta_1 \dot{z}_1 = -\ddot{y}$$

$$z_2 + \left(\frac{K_2}{M_2} + \frac{K_3}{M_2} \right) z_2 - \frac{K_3}{M_2} z_1 + 2\omega_2 \beta_2 \dot{z}_2 = -\ddot{y} \tag{3}$$

Which after the substitution:

$$\omega_1 = \frac{K_1}{M_1}, \quad \lambda_1 = \frac{K_3}{M_1} = \omega_1^2 \frac{K_3}{K_1}$$

$$\omega_2 = \frac{K_2}{M_2}, \quad \lambda_2 = \frac{K_3}{M_2} = \lambda_1 \frac{M_1}{M_2} \tag{4}$$

Are transformed into the system of equations in the matrix form:

$$\begin{Bmatrix} z_1 \\ z_2 \end{Bmatrix} + \begin{bmatrix} (\omega_1^2 - \lambda_1) & -\lambda_1 \\ \lambda_2 & (\omega_2^2 - \lambda_2) \end{bmatrix} \begin{Bmatrix} z_1 \\ z_2 \end{Bmatrix} + \begin{bmatrix} 2\omega_1\beta_1 & 0 \\ 0 & 2\omega_2\beta_2 \end{bmatrix} \begin{Bmatrix} \dot{z}_1 \\ \dot{z}_2 \end{Bmatrix} = \begin{Bmatrix} -\ddot{y} \\ -\ddot{y} \end{Bmatrix} \tag{5}$$

For the adopted change of rigidity and designation from the equation (1) the following is obtained:

$$\underset{\sim}{M}\, \ddot{z} + \underset{\sim}{K}\, z + \underset{\sim}{C}\, \dot{z} = \underset{\sim}{R_t}, \quad u_1 = z_1$$

$$u_2 = z_2 \tag{6}$$

That is:

$$\underset{\sim}{M}\, \ddot{u}_t + \underset{\sim}{K}\, u_t + \underset{\sim}{C}\, \dot{u}_t = \underset{\sim}{R_t} \tag{7}$$

The equation (7) relates to the arbitrary time t, for the time increment Δt, that is, in the time $t+\Delta t$, of the same equation, the following matrix form will be obtained:

$$\underset{\sim}{M}\, \ddot{u}_{t+\Delta t} + \underset{\sim}{K}\, u_{t+\Delta t} + \underset{\sim}{C}\, \dot{u}_{t+\Delta t} = \underset{\sim}{R_{t+\Delta t}} \tag{8}$$

The incremental form of movement equations is considerably favorable for analysis of non-linear problems, so when the equation (7) is subtracted from the equation (8) the result is:

$$\underset{\sim}{M}\, \Delta\ddot{u}_t + \underset{\sim}{K}\, \Delta u_t + \underset{\sim}{C}\, \Delta\dot{u}_t = \underset{\sim}{R_{t+\Delta t}} - \underset{\sim}{R_t} + \underset{\sim}{R_t^r} \tag{9}$$

Where vectors $\Delta\ddot{u}_t$, $\Delta\acute{u}_t$ and Δu_t, represent the increment of acceleration, increment of velocity and increment of displacement in the time interval Δt, and they are defined as:

$$\Delta\ddot{u}_t = \Delta\ddot{u}_{t+\Delta t} - \ddot{u}_t$$

$$\Delta\dot{u}_t = \Delta\dot{u}_{t+\Delta t} - \dot{u}_t$$

$$\Delta u_t = \Delta u_{t+\Delta t} - u_t \tag{10}$$

$\underset{\sim}{R}_t^r$ - is the vector of retained forces at the end of time *t*, which is obtained approximately.

$$\underset{\sim}{R}_t^r = \underset{\sim}{R}_t - \underset{\sim}{M}\,\underset{\sim}{\ddot{u}}_t - \underset{\sim}{C}\,\underset{\sim}{\dot{u}}_t - \underset{\sim}{F}_t \tag{11}$$

where: $\underset{\sim}{F}_t$ - is the vector of internal forces, that is $\underset{\sim}{F}_t = \underset{\sim}{K}\,\underset{\sim}{u}_t$.

For the elastic systems, by substituting the equation (11) in the equation (9) the following is obtained:

$$\underset{\sim}{M}\,\Delta\underset{\sim}{\ddot{u}}_t + \underset{\sim}{K}_t\,\Delta\underset{\sim}{u}_t + \underset{\sim}{C}_t\,\Delta\underset{\sim}{\dot{u}}_t = \underset{\sim}{R}_{t+\Delta t} - \underset{\sim}{M}\,\underset{\sim}{\ddot{u}}_t - \underset{\sim}{C}\,\underset{\sim}{\dot{u}}_t - \underset{\sim}{F}_t \tag{12}$$

Determination of the dynamic response is performed by solving the equation (12) buy direct integration "step by step .

For solution of the equation (12) the Newmark's β method of generalized acceleration. During $\beta_N = 1/6$ a linear change of acceleration in the interval is obtained, and the method is unconditionally stable. Two parameters α and β are used, which produce the amount of acceleration at the end of the interval, and which are used in the terms of velocities and displacements. For the described mathematical model (Fig.2) the software was developed [2] (in IZIIS, in Skopje) for determination of the dynamic response of the system with multiple degrees of freedom.

The main software, in each time step, calculates $\underset{\sim}{R}_t$ and $\underset{\sim}{F}_t$ and forms the force vector with their aid. In this way, the behavior of a bridge with multiple spans [3] at the influence of seismic actions was analyzed, and the actual effects of earthquakes on the bearings of various characteristics. The analysis results demonstrated that the influence of bearings is of extraordinary importance for the structural behavior at dynamic (seismic) load.

Therefore, the design of the bearing of massive importance for the behavior of the entire bridge structure. If the continuity is not realized and the expansion joint between the adjacent spans is not installed, each column or every other column receives the total braking force and other horizontal forces, which is a very poor solution, particularly when the columns are high. It is a much more favorite situation if the forces are simultaneously transferred to all the columns, proportional to their rigidity. In this way, significantly lower shearing forces in the neoprene bearings are generated, so they can be considerably lower, that is, thinner.

By connecting the prefabricated elements of the bridge, an inter-space in the form of a clearance or joint is formed, which in a suitable way composes a desired structural system. Joints and connections significantly affect the production, transport and assembly processes, often determining the general properties of a structural system in service. For this reason, the issue of design and calculation of joints and connections components must be paid due attention, in order to a reach the best solution. Various methods of connections, in terms of accepting and transferring loads, can alter the static and dynamic patterns of structural systems, which is yet another reason for their detailed analysis [4].

The structural joints serve to connect the individual elements into a whole and to provide the integrity of the structure for all the anticipated loads including those which can occur in incidental situations (earthquakes, floods etc.). The joints, by their flexibility and structural shape should accept the deformations occurring due to the temperature changes, of contraction and creep of the concrete, settling of the subsoil, they should exclude the possibility of onset of cracks due to the strain of connected elements and to ensure the easy assembly and tightness of the joint, and to provide the durable continuity of the carriageway sections at the joints. These requirements are met applying various types of continuity structures. The joints between the beams of adjacent spans of prefabricated beam bridges had a variety of designs: inexpensive expansion structure of copper sheets sealed with bitumen or asphalt putty, expansion joints of various structures, construction of the partial continuity of asphalt carriageway course, as well as the subsequent construction of the continuity of span structures support.

The expansion joints are the frequent forms of continuity structures when designing the joints of adjacent spans, but they are susceptible to various forms of damage and destruction.

Bridge expansion structure must accept in service, with no onset of damage and destruction, various deformations (displacements and rotations), depending on the arrangement of dilatations in the very bridge structure. They must ensure as smooth transition of vehicles as possible, and its upper surface must be in level with the carriageway after installment and later in service. Such conditions are difficult to satisfy.

For instance, the neoprene band inserted and attached with bolts to the immovable steel parts, prevents passage of water and dirt, but is not durable and strong as the steel parts.

Therefore, dilatation devices represent a sudden interruption of continuity of the carriageway course, and thus present a serious obstacle to traffic, even if they have been very skillfully constructed and correctly installed. After the passage of a vehicle, due to the vacuum created by the pneumatics, the concrete or asphalt course crumbles, which leads to development of greater damage rendering the joint permeable for water. If the joint damage is not tackled in good time, the bearing operation might be endangered, which causes significant damage of material and structure (concrete corrosion, frost action, etc.).

Interruption of the asphalt and concrete course at the expansion joint is always a favorable place for occurrence of damage [4]. It is clear that the most frequent way of connection of „simple beam" bridge structures with multiple spans, where displacements are relatively small (Fig.3). The wearing course is of the cast asphalt with addition of rubber, reinforced with steel mesh, as otherwise damage as in the figure 3 may occur.

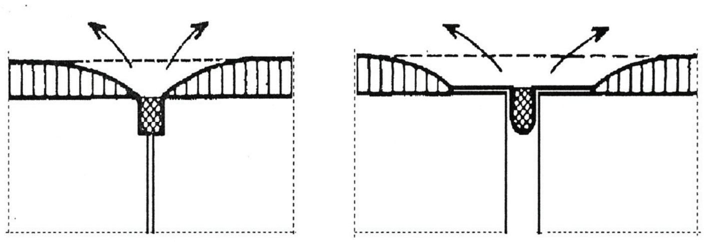

Fig. 3 Damage of wearing course

The joints of the beams of adjacent spans via expansion and other joints, are not only sensitive and weak spots of the bridge structures, but also a liability for cars and traffic in general. Any such location causes a more or less stress for the vehicle transiting over it, damaging in the process the vehicle wheels, axles, and the steering, suspension and transmission mechanisms, etc.

Aiming for the enhancement of expansion joints structures in the bridges carriageways the researchers incessantly make efforts to find new improvement of technological solutions. The latest solutions, which overcome certain technical shortcomings, such as expansion joints for great displacements, are constantly being improved and enhanced. Such example is the expansion joint «THORMA-JOINT» from England (for small and medium expansions).

For very high displacements, the so called «Rolo» expansions are applied. A special form of expansion joints are dams which can significantly expand, have good driving characteristics, and are easy to maintain. These expansion joints are not suitable for many structures and applications. The reason or this is their great thickness and height, because they are fabricated of cast steel. In addition, the teeth of the dam have narrow spacing, so as to prevent the bicycle wheels or shoe heels from getting in between etc.

There are expansion joints permeable to water (for instance "Rolo"), so an appropriate protection and drainage of the lower parts of structures must be provided for, as well as access to them, and except this, the joint is complicated, expensive and maintenance and potential repair are difficult.

There is a number of companies manufacturing expansion joints, such as *Gutehoffnugshűtte* (GHH), GHH- Transflex for large displacements (330mm), *Maurer Söhne*, and other [5].

In our country, Mostogradnja of Belgrade manufactures and uses several types of expansion joints, as well as bearings of bridge structures.

Continuation of prefabricated pre-stressed concrete bridges, via soft reinforcement installed longitudinally in the slab cast in situ, above the medium supports, that is, columns, is a procedure that has been applied in our country for a long period [6], and the «Portland Cement Association» from Illinois in the USA conducts extensive experimental research, whose results confirmed the rationale of this idea [7]. In our country, the fundamental research conducted by the design of Prof. Dimitrije Ćertić [8] [9] proving that these structures are very cost-efficient and that additional interventions in realization of this form of continuity are very simple. This procedure was applied in a number of bridges constructed in the country and abroad by the Construction Enterprise "Mostogradnja" of Belgrade [10].

In design of the bridge structures, according to the functional and aesthetic requirements of the design specifications, and depending on the collected documents, it is of utmost importance to firstly correctly select a disposition design of the bridge structure as well as the construction material, so that it is both technically and financially optimal. In order to complete this complex task, it is necessary to conduct detailed analyses of several alternative designs. A detailed analysis of all actions and the possible combinations of actions must be performed, for all the construction and service phases. From this, the best idealized models approximating the bridge structure must be chosen.

Modeling of expansion joints has not been paid due attention until now, at least in our country. Modern expansion structures, to a certain extent connect the individual structures of the bridge, which is a fact that should be taken into account during design, and the joints should be adequately designed. Expansion joints, which are regularly installed in the long bridges for structural reasons and to provide for thermal dilatation effects, have a great influence, as it has been said, on the structural integrity of the overall system under dynamic influences and seismic load of bridge structures.

For simulation of actual behavior of expansion joints, under action of various influences, a number of models and specific types of finite and boundary elements have been developed worldwide, that to a greater or lesser extent successfully solve the issue. One among the first is the analytic model for simulation of dynamic load of expansion joints in long bridges with multiple spans [13] whose authors are W. S. Tseng from San Francisco and J. Penzien from the Earthquake Engineering Research Center of the University of Berkeley, California. The design of the analytic model is similar to the previously presented design of bearings.

By construction of the completely continuous joint of adjacent spans, the structural system of prefabricated beam bridges assumes a new static and dynamic treatment of a continuous "beam" for all the loads that might ensue. In this way is provided a much more cost-effective and rational design of the bridges, which provide a permanent continuity of transition in the carriageway at the places where the beams of the adjacent spans are connected, and thus also the better driving and service characteristics of the bride as an engineering structure. The stress-strain behavior of the reinforced concrete and pre-stressed structural elements of the continuous joints of adjacent spans, is a function of a number of parameters, some of which not being sufficiently reliably known at the time of designing the bridge structure. Implementation of non-linear analysis and computer technology, it is possible to numerically simulate the influence of certain parameters and so obtain a considerably factual prediction of the actual behavior of these structures. The commercial software with such options (for example: ADINA, NONSAP, NISA, ANSYS, Drain 3D, TABS, FEM, NORA etc.) are here widely used, especially in modeling geometrical and material non-linearity. However, since the potential for realization of complex non-linear analyses are not accessible to wider circles of designing engineers, nowadays the simplified design procedures are mostly applied, as they are convenient to use in design.

The still standing codebook [14] pays a minimum attention to bridge structures. The Codebook draft [15] which is fairly complicated for usage, has not been widely implemented in national practice.

In order to conduct a complex non-linear analysis, apart from a powerful computer and the appropriate software, a considerably higher level of theoretical knowledge is required, than normally accumulated through the studies and subsequent designing practice [10].

For this reason, the data for seismic design of the bridge structures, must take into account the dynamic behavior of bridge structures and adequate modeling of foundations and superstructure and substructure of bridges, when analyzing the dynamic response. Also, the suitable procedures should take into consideration the interaction of the bridge structures with soil, as well as the actual nature of the seismic action through the high-elasto-plastic behavior of individual elements of the system taking into account the rheological properties of constitutive materials.

When aiming to reduce to the minimum the damage of bridge structures occurring due to the action of static, dynamic and seismic loads in the future, it is particularly important to determine the structural dynamic and seismic risks and to provide guidelines for reinforcement of the already constructed bridges, particularly of those which connect the traffic routs of special importance for the economy and which are crucial for supplying help in post-disaster situations (after earthquakes). In the simplified procedures, the calculation result is not an accurately predicted value of influence, by rather the expected value. The accuracy sought however, is to describe the actual behavior of bridge structures under action of the given load. As the goal of the research is to create a potential to calculate the real, actual behavior of structures, in this case prefabricated beam bridges, it is necessary to analyze all the important influential factors of their specific behavior. As it was mentioned several times, the bearing and expansion joints behavior influences are especially important elements of design of any bridge structure.

4. Designing of Seismically Resistant Bridge Structures According to Eurocode 8

In the draft of the Eurocode 8 have been emphasized the fundamental goals and requirements formulated in the EC 8, with the accent of on the presentation of the local soil conditions and defining of the relevant seismic parameters [16], [19]. Determination of elastic and design spectra has been presented in detail as well as the alternative types, such as the power spectra and timeline.

A part of the EC 8 devoted to bridges comprises criteria and regulations for application in aseismic designing of bridges. It can be assumed that the seismic actions are the most challenging for the design of bridges. This document [16], [17] except for the introduction, has the following chapters: Basic requirements and harmonized criteria, Earthquake actions, analysis, Bearing capacity evidence, Specific regulations for details, Vibro-isolation of bridges etc. Apart from that, four informative additions are made: Choice of design earthquakes, Relation of displacement ductility and curve of plastic joints in reinforced concrete columns, Evaluation of the rigidity effect of reinforced ductile elements and Spatial changeability and rational components of soil movement caused by earthquakes, as well as the normative appendices, of which one is Testing of the prototype of bridge isolation systems. The provisions primarily refer to the bridges where the horizontal actions are mostly received transferred to the bank columns or by bending columns, whereas the traffic load is received by the carriageway structures.

The requirement is made not to form the plastic joints in the carriageway structure, and that there will be no falling off the bearings during extreme displacement.

Ductile behavior during earthquake can be realized by the application of isolation in foundations and using the special elements for energy dissipation [18]. The number of bank and medium columns receiving the horizontal forces should be determined taking into account the necessity to receive seismic forces in longitudinal and transversal directions. Their number can be reduced using the flexible joints at the locations of connections with beams. It is necessary to realize a necessary balance between the requirements for flexibility and rigidity of support bearings. The flexible bearings reduce the seismic effects in columns, but they allow great displacements which can lead to the undesirable effects of another kind. The seismic aspect can be very important for some elements, particularly for the bearings. Application of the concept of ductile behavior of bridges during seismic excitation can be realized by forming the dependant plastic mechanisms (joints), applying the basic isolation or using the special energy dissipation elements. The choice of such concept imposes some aspects which must be separately considered.

In EC 8 it is required that the national territories are divided into seismic zones, depending on the seismic activity system with the maximum acceleration of soil on the bedrock being constant for the entire zone. It is considered that this parameter can include the level of vulnerability of the structure, which can be fully justified. The maps are given for the adopted return period of |475| years and the significance factor is dependent on the importance of the bridge: higher than average |1,30|, average |1,00| and lower than average |0,70|.

Separately defined are: connections, displacement control – details, modeling, analysis methods, bearing capacity evidence, bridges with isolation devices etc. [19].

5. Conclusion

The contemporary trend of civil engineering development, and bridge-building in particular, is directed toward the complete rationalization of construction. For these reasons, in the recent period, in our country and abroad, it is required that the bridges and other civil engineering structures be designed according to the modern technical-technological and scientific findings. The issue treated hire, and particularly continuation of adjacent spans of prefabricated beam bridges obtains extraordinary importance, because it provides the durable continuity of transition in the carriageway in the places where the beams are connected, their construction being extremely cost-effecting, and with better driving and service characteristics and having the increased durability of structures.

Earthquake effects on the bridge structures are transferred from the substructure, via bearing, to the superstructure, and the service load is transferred the opposite direction. Damage to the superstructure and substructure could be reduced by adequate design of bearings and expansion devices. Expansion devices in the mentioned types of structures should be applied only in the positions where they cannot be avoided by other solutions. Their number should be reduced to the minimum. As the disposition of the connections of prefabricated beams of adjacent beams and continuity structures over the expansion joints depends mostly on the magnitude of expansion, and on the fact whether the discontinuity of the carriageway in the location is desired, there is a pronounced need for a more intensive theoretical and experimental research of this issue.

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KONSTRUISANJE OSLONAČKIH ZONA BETONSKIH MOSTOVA ZA UTICAJE DELOVANJA STATIČKOG I DINAMIČKOG OPTEREĆENJA

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U radu će biti prikazana neka od stečenih iskustva projektovanja i građenja mostovskih konstrukcija iz više zemalja, sa posebnim osvrtom na analizu ponašanja oslonaca i dilatacionih spojeva određenog broja drumskih mostova. Pri oštećenju i rušenju konstrukcija mostova postoji relativno mala verovatnoća, mada nije isključeno, da direktno budu ugroženi ljudski životi (Kobe, Japan 17.01.1995. godine); ali nastaju teškoće pri ukazivanju pomoći povređenima u tom regionu. Obzirom što karakteristike razmicanja oslonaca imaju veliki uticaj na ponašanje cele mostovske konstrukcije, to se konstruisanju osloničkih veza i spojeva mora posvetiti odgovarajuća pažnja. Poslednjih decenija čine se napori ka povećanom izučavanju svih inžinjerskih konstrukcija, pa samim tim i konstrukcija mostova i njihovih slabih mesta.

Ključne reči: *mostovi, ležišta, dilatacione sprave, proračun*