Special Lateral Seismic Joints on Bridges

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ABSTRACT

Bridges are some of the most important structures in infrastructure and transportation system. They are design to sustains traffic loads and environmental actions. The selection of structural type and joints details are a challenge for structural engineer. Different structures types behaves in a different ways. A statically determine structures give a good behaviour to environmental action as temperature and ground displacement. Usually they are indifferent to this action, but they do not give a good performance due to earthquake loading. On the other side, the statically undetermined structures, gives a good performance due to earthquake action, but they express additional stresses under the change in temperature or ground displacement.

So, it's wise to think for intelligent structures, which demonstrate the best characteristics and behaviour under different types of loadings and actions. In this study is observed the behaviour of transportation bridge with a traditional joints and intelligent joints.

The intelligent joints consist of a dashpot filled with high viscose silicon. To the low rate of velocities, the silicon can flow through the chambers of dashpot without resistance. For high rate of velocities, the silicon react as solid body and prohibit the movement.

Mounting this dashpot in bridge joint, depending upon the rate velocities of the movement, the structures will react in intelligent manner. Under the temperature gradient, the rates are to slow, and the dashpot does not act as a restrain. Under the seismic loads, the rates are rather high, and the dashpot act as a restrain. So, we got the same structures, but behaving accordantly to the loading or actions exposed.

Through different case analyses, the behaviour of the structures is observed. Some essentials results and comments are derived.

Keywords: *Tune Mass Damper, Modal Analysis, Time History.*

INTRODUCTION

The bridge that is being studied has a box girder section from AASHTO standards with: B=11.4m and h=2.7m. This bridge is composed of three spans, two shoulders and two piles. Spans have an equal length to l=40m and piles have got both the same height h=12m. The overall height of the bridge is L=120m, width B=11.4m and height H=15m.

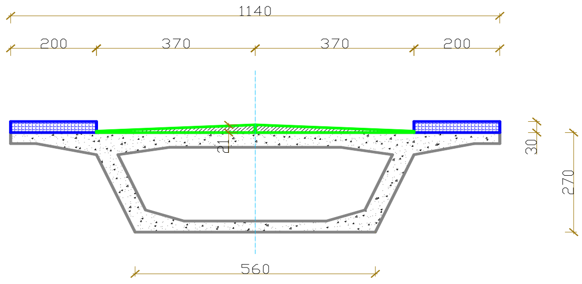


Figure 1 Design cross section

- **Cross-section copounds:**

1 – two pavements, width b1 = 200 cm, and height h1 = 30 cm
2 – two crossing lines, width b1 = 370 cm

- **Layers:**

1 – 10 cm asphalt
2 – 5 cm concrete
3 – 1.5 cm isolation
3 – 5 cm levelling concrete layer

The study is focused on seismic behaviour of bridge special joints. So, for that reason we have not specified where this bridge is situated and other details.

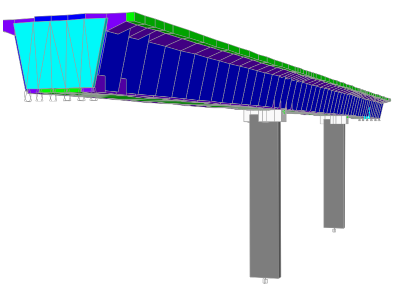


Figure 2 3-D view of the bridge

CASE STUDIES

We have used two static scheme types to study the dynamic behaviour of the bridge as a function of the restrain type.

Scheme type I

First scheme type has got these restrains : shoulders are pinned with degree of freedom that allow horizontal displacement. The superstructure is pinned to piles that do not allow any translative displacement.

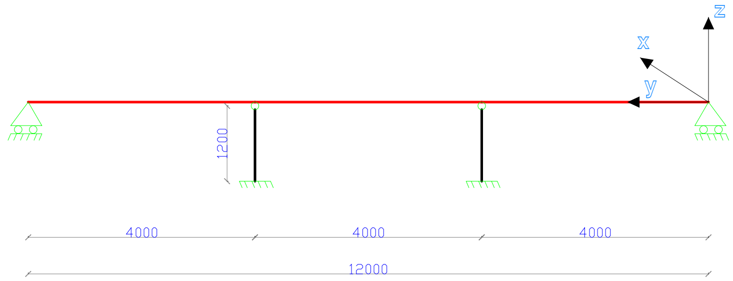


Figure 3 Calculus scheme 1

Scheme type II

Second scheme type has got these restrains: shoulders are fixed in that particular way with the bridge that do not allow any displacement. The restrain corresponded to piles do not allow any displacement.

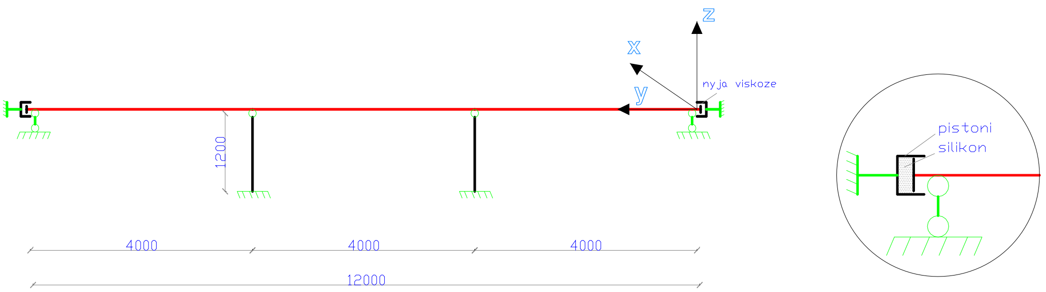


Figure 4 Calculus scheme 2

Viscous joint is a specific restrain which becomes a fixed joint after the seismic force is applied due to its certain construction with silicon, which hardens from the dynamic action of the force, reacts as solid body and prohibit the movement.

Concrete characteristics

The concrete used in the bridge structures has got usually a cubic resistance of 28 days which varies from 40 Mpa to 60 Mpa, in our particular case is used concrete with cubic resistance of 28 days 45 Mpa. Some of the concrete characteristics used in our model are shown below.

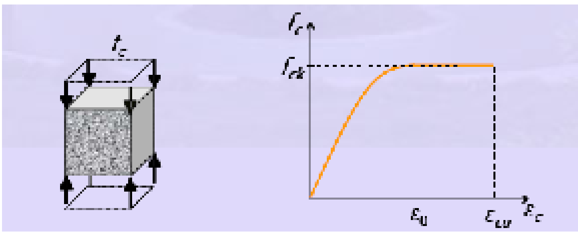


Figure 5 Concrete stress-strain diagram

f_{ck}= 35 N/mm^2
f_{ck}: cylindrical resistence of concrete in compression
f_{cm}= 43 N/mm^2
f_{cm}: the minimum value of cubic resistence in compression
fcd= 23.3 N/mm^2
fcd: the design value of cylindrical resistence of concrete in compression

Steel characteristics

The steel used in the bridge structures varies from 400 Mpa to 500 Mpa,while Yungs module varies from 190 000 to 210 000 Mpa. In our particular case is used steel whith these characteristics: fs=500 MPa

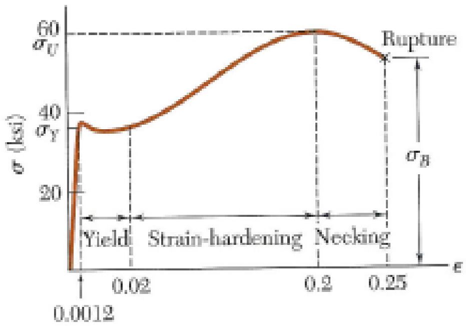


Figure 6 Steel stress-strain diagram

Prior assessing dimensions of the structure

Minimal depth of the cross section is given:

- for sigle spaced structures $\mathbf{h_{min}=0.06\ L}$
- for continous spaced structures $\mathbf{h_{min}=0.055\ L=2.2\ m}$**,** assuming **h=2.7 m**. (1)

where "L" is the span length

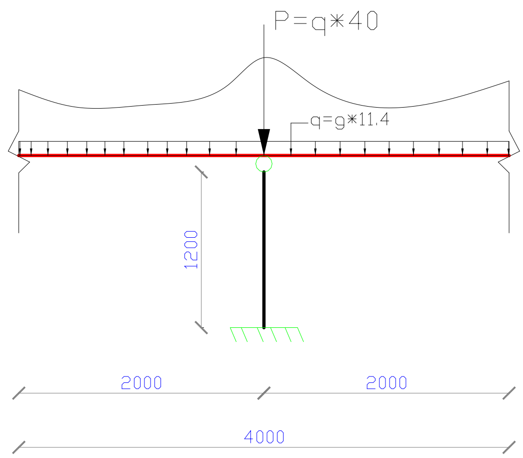


Figure 7 Load scheme

P = g * 11.4 *40 = 30.9*11.4*40 ≈ **18000 KN** (2)

Dimensions assessment of the pile.

$$\frac{N}{A} \leq 0.55\,X\,\frac{fc}{\gamma c} \quad \text{yield } A=1.7\text{m}^2 \qquad (3)$$

γc — partial coeficient for concrete , γc = 1.5
P — axial force acting on the pile. N ≈ 18000 KN
A —cross section area of pile

We accept these dimensions: b = 2 m , h = 1 m.

Ground conditions and seismic action

For these case studies assume the ground category ”D” as descrides on the eurocode normatives with PGA=1.5m/s^2 and q=1.5 (moderate earthquake). Based on these normatives we do the dynamic analisys of the structure.

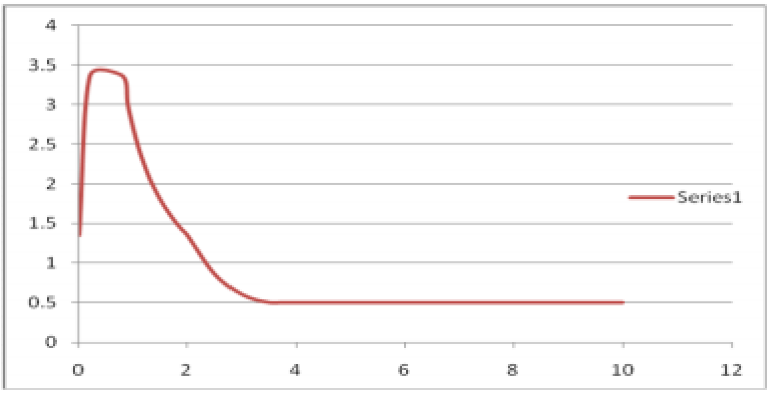


Figure 8 Ground acceleration chart

Table 1 Characteristics of ground category

Ground category	S	TB(S)	TC(S)	TD(S)
D	1.35	0.20	0.8	2.0

STRUCTURE ANALYSIS

We have modelled the structure in SAP-2000 software computer programme. The finite elements used are as followed:

- frame element — bridge piles (columns)
- shell thick — deck section (supestructure)
- link element — restrain (special joints)

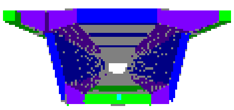


Figure 9 Cross section of the bridge

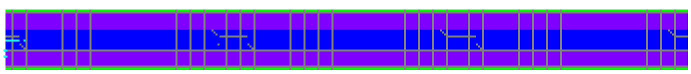


Figure 10 View from the top side

In order to gain accurate results we refine mesh the shell elements into smaller-sized near its supports. The static loads are apply as surface load in the superstructure slab.

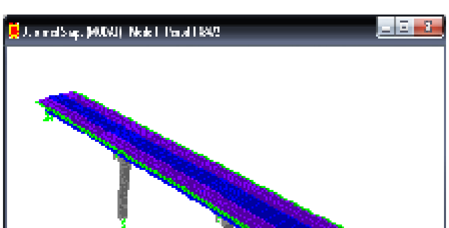
Static Analysis

We have study the bridge response under the permanent load action. The self weight is generated automatically from the program. Layers, pavements and installations loads are apply as surface loads with corresponding magnitude. In the same way are calculated the structure masses.

Because both schemes have the same behaviour under static loads, only one analyse is performed.

Dynamic Analysis

To get the seismic behaviour, first the dynamic analysis are done. In these case the special joints react in different manner. So, two dynamic analyses are run that correspond to Scheme I and Scheme II. As results, the dynamic characteristics are taken for both structures.



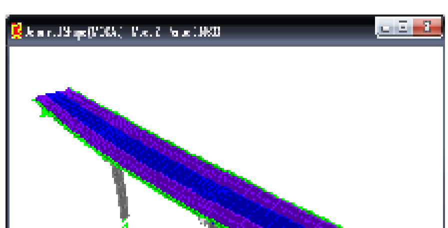


Figure 11 Deformed shape mode 1(Sch.1)

Figure 12 Deformed shape mode 2 (Sch.1)

Table 2 Perods of free vibration for Scheme I

Mode	1	2	3	4
Period	1.43	0.6	0.3	0.26

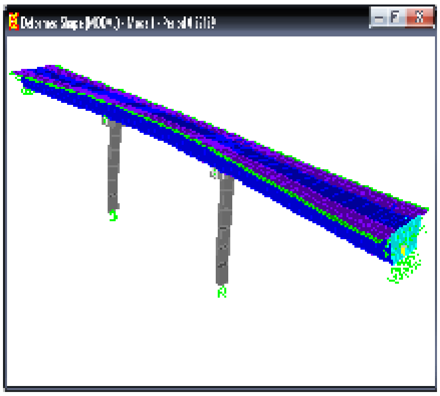


Figure 13 Deformed shape mode 1(Sch.2)

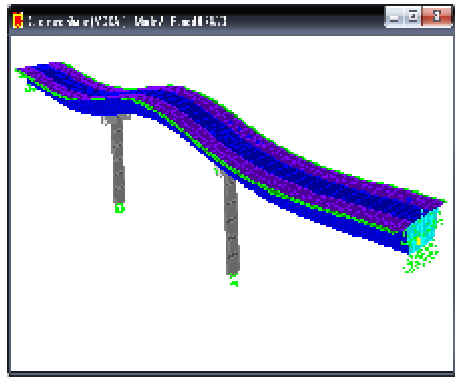


Figure 14 Deformed shape mode 1(Sch.2)

Table 3 Perods of free vibration for Scheme II

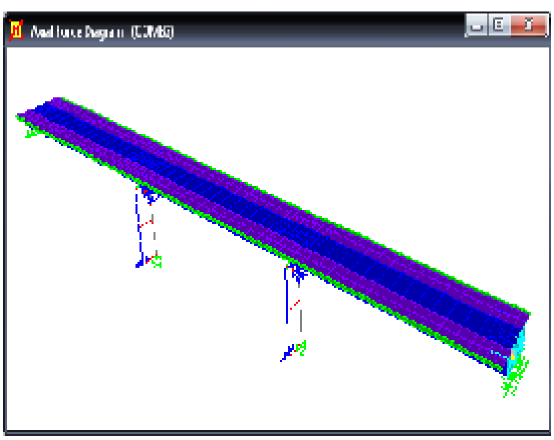
Mode	1	2	3	4
Period	0.39	0.24	0.19	0.17

Seismic analysis

The seismic analysis are carrying out by use of modal superposition response spectrum analyse. The SRSS method is used. The load combination are those described in EC-8 as below given.

$$\text{COMB 1} = 1.0 * \text{DEAD} + 1.0 * E_x + 0.3 * E_y \quad (4)$$

$$\text{COMB 2} = 1.0 * \text{DEAD} + 0.3 * E_x + 1.0 * E_y \quad (5)$$



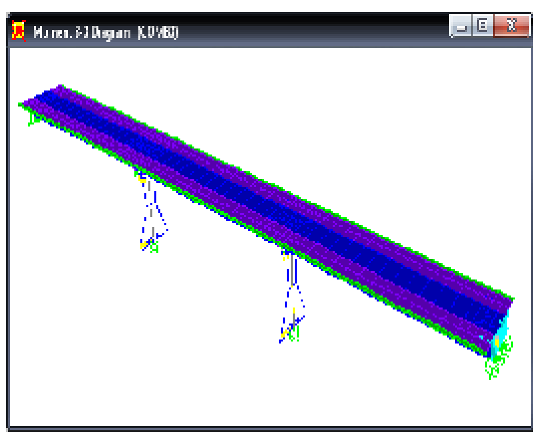


Figure 15 Axial forces in piles N1=17000 KN

Figure 16 Bending moment in piles M1=19100 KNm

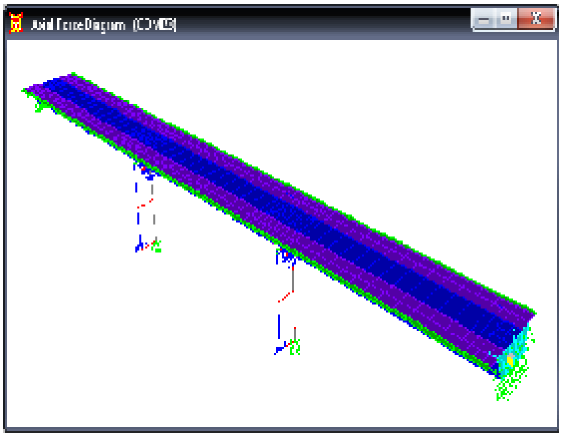


Figure 17 Axial forces in piles N2=16000 KN

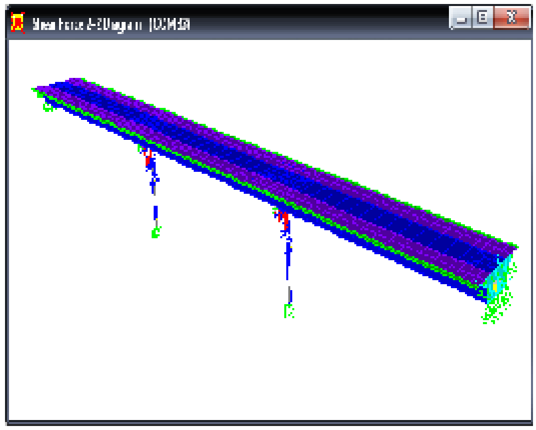


Figure 18 Shear force in piles Q1=2326 KN

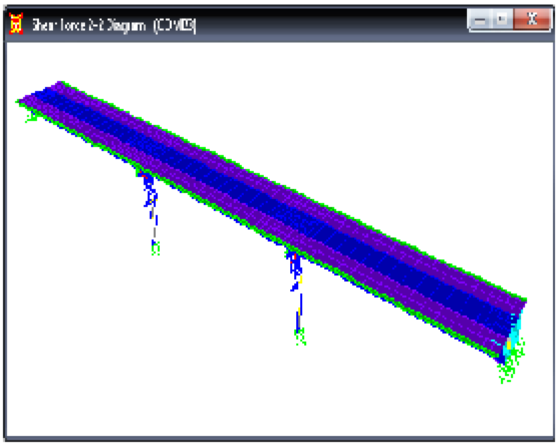


Figure 19 Shear forces in piles Q2=850 KN

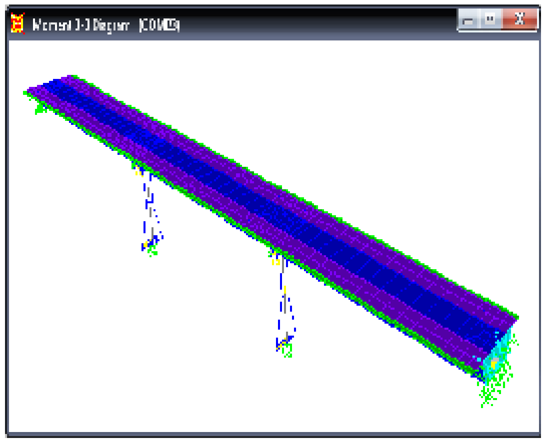


Figure 20 Bending moment in piles M2=7310 KNm

COMPARISONS AND RESULTS

To reach a conclusion regarding the dynamic analysis of type box bridges and the seismic effect on the distribution of internal forces is important to make a substantial difference on the two restrain schemes of structure and the results obtained for each of these schemes .It is obvious that the configuration of the distribution of internal forces in the second scheme, compared with the first one, reveals with big values due to the grip shock absorber detail to the edges of the scheme, this reduces to a considerable extent the values of moments and increases the ability of this structure to absorb the dynamic shocks that are expected to happen. Also values of periods in the second scheme reveals clearly smaller and this fact shows that the deformations of the length of the type box bridges are comparatively smaller and within the allowed values.

CONCLUSIONS

The conclusion we achieve from this study is that the precise definition of the scheme and the rational choice of restrains, are important factors in efficient behaviour of structures. To sum up, the use of viscous joints plays an important role in the depreciation of seismic forces therefore use the second scheme in our case study is effective.

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