System DC90 - Three-axial steel hysteresis-sliding

Zoran Petraskovic
Inovacion Center Sistem DC90, comp.ltd., Belgrade, Serbia, email:dc90@eunet.rs, www.dc90.co.rs

Jasminka Petraskovic-Dzuklevski
Inovacion Center Sistem DC90, comp.ltd., Belgrade, Serbia, email:dc90@eunet.rs, www.dc90.co.rs

SUMMARY:
The proposed device is SYSTEM DC90 product capable to control energy dissipation at the supports of structures exposed to seismic forces. It is composed of sliding plate fixed to the structure and connected to three orthogonally placed hysteresis dumpers fixed to the support. In both horizontal directions the energy dissipation is achived by: a) friction of sliding plate and the supporting surface and b) the yielding of steel device in the horizontal dumpers. The dissipation in the vertical direction is accomplished by the vertically positioned hysteretic dumper. The coefficient of friction between the sliding plates may be defined in the range from 0.9% to 20%. The characteristics of hysteresis curve for the dumpers may be defined as follows: a) elastic limit from 10 kN to 5000 kN , b) the initial stiffness (elastic) from 130 000. 0 kN/m to 200 000.0 kN/m, c) after crossing the elastic limit the plastic stiffness may be defined from 3% to 17% of the initial stiffness. The range of the displacement may vary from 1.0 mm to 200.0 mm. The dumpers were extensively tested to proof their proper functioning under dynamic excitation. Special attention was directed toward fatigue longevity of the yielding element of the dumper. The dumper is adequate and may be included as a part of the support or joint in a structural system.
Keywords: Dampers, hysteresis, slidings, ductility, displacement control.

1. INTRODUCTION

At base facilities isolation it is required of the construction supports to have controlled hysteresis behavior. The three-axial hysteresis-steel sliding joint support device is made to achieve this function of controlling the force and displacement. Control of displacement is made by the metal hysteresis damper so the fatigue phenomenon is considered.

2. CONSTRUCTION OF DEVICE

Device is composed of sliding plate fixed to the structure and connected to three orthogonally placed hysteresis dumpers fixed to the support (see Figure 1.).

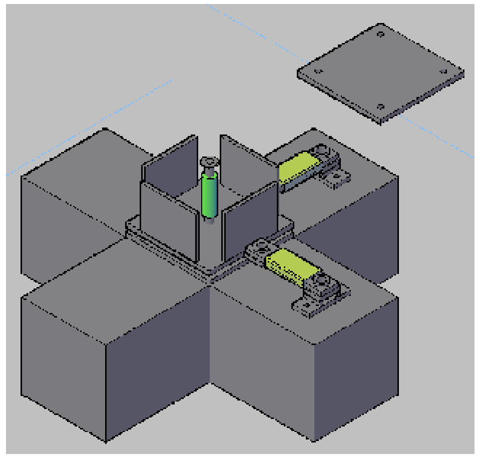
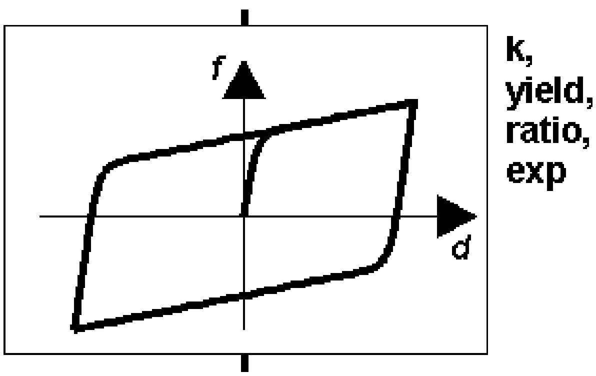


Figure 1. 3D damper device

In both horizontal directions the energy dissipation is achived by: a) friction of sliding plate and the supporting surface and b) the yielding of steel device in the horizontal dumpers. The dissipation in the vertical direction is accomplished by the vertically positioned hysteretic dumper. The dumper is adequate and may be included as a part of the support or joint in a structural system. The facts defining damper is fig2, and fig.3.



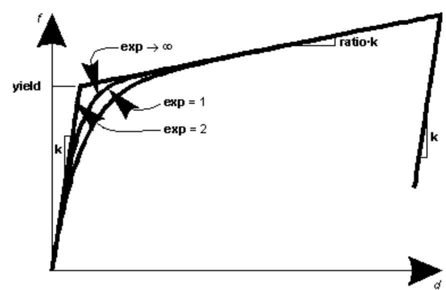


Figure 2. Hysteresis Diagram, Force vs. displacement, Figure 3. Stiffness of elements

The facts defining damper:
a) relation of stiffness in elastic zone and after it – ratio k
b) exponent by which the diagram is approximated – exp.
c) ($\varepsilon_{yield,}$ σ_{yield}) strain and stress in limit yield
The facts defininDumper type Mionica +:
k=128,712.87 kN/m
yield=120 kN
ratiok=0.11
exp=2
The fact defining Damper: SUPPORTS Sliding and histereteretic Dampers in three directions (X, Y, Z)
K=130,000.00 kN/m to 200,000.00 kN/m (for forces 80 to 500 kN)
yield=10 kN to 5.000 kN
ratiok=0.03 to 0.17

exp=2 to 3
displacement 1 mm to 200 mm.

3. HYSTERESIS BEHAVIOR IN THE FIELD OF SMALL NUMBER OF CYCLES

Dampers for DC 90 system (Fig. 4) were tested by variable loading on MTS servo-hydraulic closed-loop machine

Figure 4. Typical dampers of DC 90 system

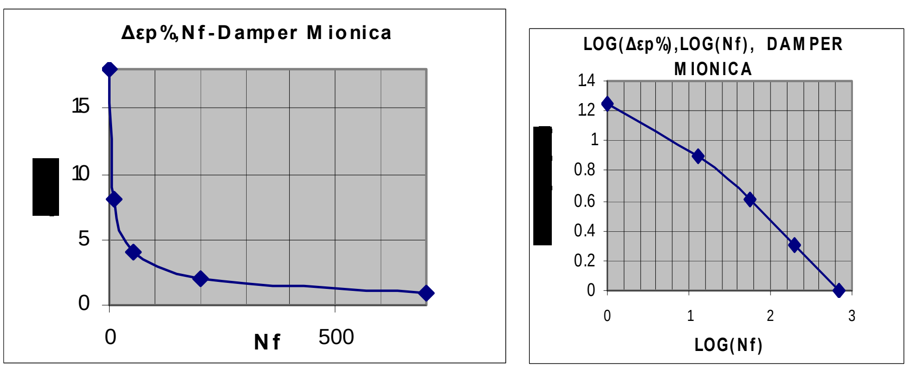


Figure 5. Number of cycles - accumulated strain diagram for „Mionica” Type Damper

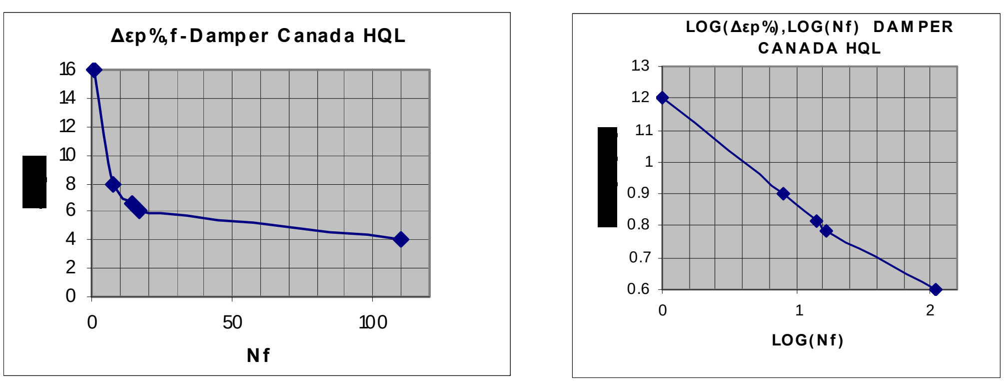
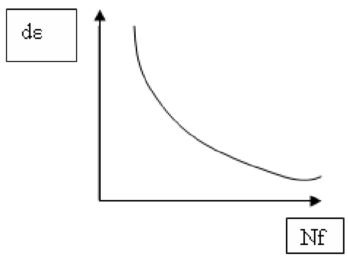


Figure 6. Number of cycles-accumulated strain diagram for “Canada HQL” Type Damper.

The Figure 5 and 6. demonstrates the relation N, ε for „Canada HQL“ and Mionica Type of Damper. The present experimental diagram is used for needs of numeric analysis and damper design.

Considering relation of dilation accumulation compared to the number of cycles and the phenomenon of the fall of stiffness compared to the size of the accumulated dilatation it is possible to predict the hysteresis behavior of construction at the moment of earthquake.

3.1. Modeling of hysteresis behavior in a small number of cycles



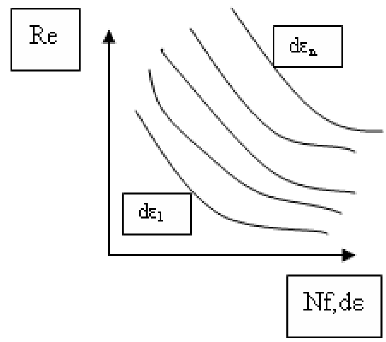


Figure 7. Diagram: Average accumulated dilation dε , number of cycles Nf, Figure 8. Diagram: Elasticity limit Re, number of cycles Nf average accumulated dilation dε, (instead of elasticity limit, Re can be seen some other parameters such as the coefficient of friction, viscous damping coefficient, the force of adhesion, e.t.c.)

This behavior is typical for the earthquake effects where the structure or certain parts lose there integrity only after a few cycles of stress. Without taking this fact into account its impossible to explain this phenomenon. The procedure of calculation with taking the effects of the accumulated dilation consists of two steps:
a. By experimentes make the curves shown at figure 7 and 8.
b. At every cycle of construction movement total accumulated dilation suppose to be calculated. It is sure that its increase with every number of cycles. For each of the current situation and the known values of (Nf, dε) read the corresponding value Re.
Change of the value Re is very slow and practically no change in the field of a large number of cycles where its fall coming sharply. But the change of the value Re in the field of accumulated dilatations with small number of cycles is large, gradual and very important. Each new cycle is calculated with the new hysteresis configuration depending on the size Re. Of course this is a simplified rheological treatment but on the other hand, trying to use simple rheological models and show a real and very complex behavior of materials under cyclic loading. Identification of key and most important parameters is essential for quality modeling.
This is especially important field for numerical modeling of new structures. The combination of numerical and experimental research is very grateful and useful. Especially in terms of price, quality (the essence of the problem) and the time required for one or another researches (numerical and experimental).

4. USE OF DEVICES ON OBJECTS

The development of this device was created as need to solve a movement control of particular objects, figure 9.

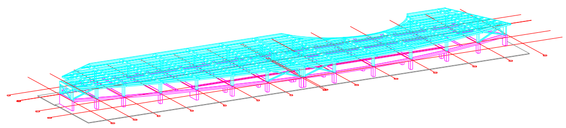


Figure 9. Construction with supporters 3D Sistem DC90

Installed devices at construction supports provide construction movement control during the earthquake. Particularly important characteristics of the devices is to limit maximum movement and change rigidity through the time. That is the way to change dynamic characteristics and avoids resonance condition (matches of object oscillation frequency with the dominant frequency of ground movement).

Figure 10. Assortiment Damper type Sistem DC90

At figure 10. show the assortiment of Dampers of DC90 developed, protected by patents and applied to facilities on four continents. All dampers are metal hysteresis with movement control. They are used for masonry, reinforced concrete and steel skeleton constructions also at the bridge constructions..

5. CONCLUSIONS

The new design of 3D Device DC90 lets you control the movement of construction support in three directions. Detail experimental model and numerical research of hysteresis behavior in the field of small number of cycles can make the effects of this device to increase the safety of the facility. Using of developed and tested devices DC90, such as multilayer metal hysteresis damper, line dumper and sickle dumper, this research can be solved in optimal time and with acceptable costs.

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