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Special Pattern of Hydraulic Dissipation System used for Isolation of Bridges against Earthquakes

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The construction sector experienced a constant evolution over time, so that today structures can be made to withstand earthquakes of considerable magnitude. This can be achieved by using various methods to counteract the direct earthquake destructive action on the construction. The methods consist of using insulation systems or earthquake energy dissipation devices that have occurred in time, being in constant development and improvement. In this paper it is presented a model of a hydraulic dissipation device as an assembly of a linear motor with fluid, which can be mounted to the structural frame of a bridge, in order to take some of the earthquake energy when it occurs, so that the bridge superstructure is protected against from high magnitude damages.

Keywords: *hydraulic dissipation device, mechanical system, fluid dynamics, 3D modeling, CFD analysis*

1. Introduction.

A bridge-type structure represents a connecting path across a water course between the human communities, as well as a complex infrastructure work in a particular region. That is why such a construction has to be maintained in operability parameters over a long period of time, being able to withstand the dynamic actions of road or rail traffic, but also intense and varied seismic actions.

Thus, in order to achieve these objectives, a bridge structures are equipped with special mechanical systems which provide them an improved behavior when are subjected by loads in dynamic regime. These devices are presented as dissipative hydraulic systems of cylinder with piston type, operating on the basis of a hydraulic fluid having special properties of viscosity and compressibility, through which energy consumption from the total earthquake energy amount can be achieved, being able of transforming into another form of energy, namely heat.

2. Assembly model for the hydraulic dissipation device.

The overall model of a hydraulic dissipative system is shown as a cylinder with piston. The cylinder is filled with silicone oil, a fluid with special viscosity and compressibility properties, which provides the damping special properties of the hydraulic device.

The main functional parameter for a hydraulic seismic energy dissipative system is the resulting force at the piston rod that is dependent on the relative velocity between the two mounting flanges positioned at the extremities.

The relationship that governs the operation of this system type is the relationship between piston rod force and the piston displacement velocity, which also depends on the characteristics of the working fluid: [3]

$$F = C|v|^{a}\,\mathrm{sgn}(v) \tag{1}$$

where: v - the relative velocity between the two joints of the hydraulic dissipative device;

C - damping constant.

Figure 1 shows the hydraulic dissipation device assembly model.

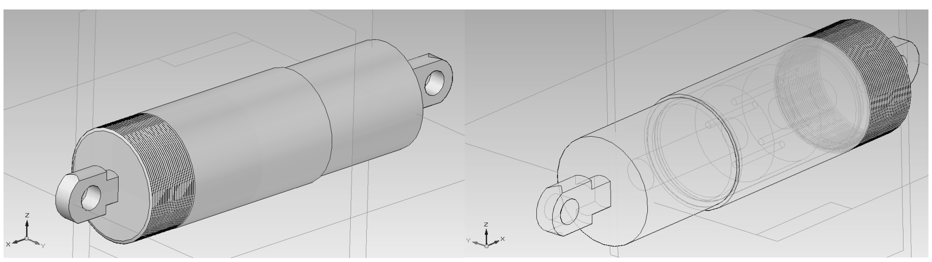


Figure 1. Dissipation device assembly

Inside the cylinder is centrally located the piston with a number of 4 circular orifices that allow the working fluid circulation when a movement is applied at the hydraulic device ends. The piston divides the cylinder into two distinct chambers. When there is a tendency to move the piston, the fluid is forced to circulate from a chamber into the other through the passage orifices.

This hydraulic device is to be mounted at bridges with one end at the foundation and the other end at the superstructure or bridge pass-way.

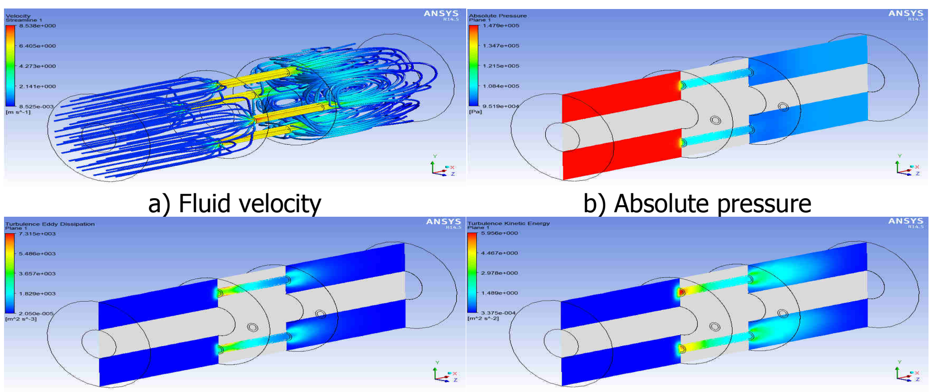
When a seismic motion occurs, the foundation moves along with the ground while the superstructure is subjected to a damping displacement by the means of the hydraulic dissipative system.

This device consumes energy by means of forced displacement of the piston immersed in hydraulic fluid due to the compressibility and viscosity properties of the working fluid.

3. Numerical analysis for the hydraulic dissipation device virtual operation.

For the virtual model built, a numerical analysis was performed in order to highlight the circulation of the working fluid inside the hydraulic cylinder by means of the specific parameters involved in this type of energy dissipating device operation. A translational motion of the piston was declared at a velocity of 0.3 m / s inside the cylinder.

The calculation was performed for each viscosity value with the same value of the piston displacement velocity. The results obtained with respect to velocity distributions, absolute pressure and turbulence are shown in Figure 2 and the effective values for the working fluid velocity, absolute pressure and piston force are shown in Table 1. [4]



a) Fluid velocity b) Absolute pressure

c) Turbulence eddy dissipation d) Turbulence kinetic energy

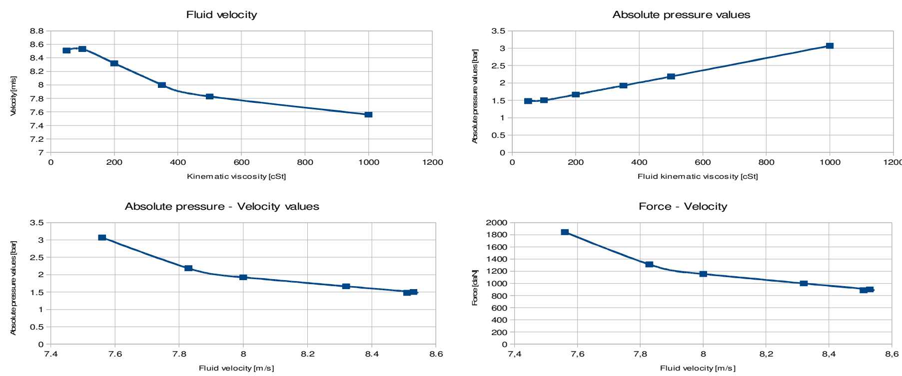
Figure 2. The analysis results for the hydraulic dissipation system

Table 1. The silicon oil viscosity values and analysis result values

Siliconic oil viscosity [cSt]	Maximum values of fluid velocity [m/s]	Absolute pressure values [bar]	The piston force values [daN]
50	8.51	1.48	888.0888
100	8.53	1.5	900.09
200	8.32	1.665	999.0999
350	8	1.924	1154.51544
500	7.829	2.185	1311.1311
1000	7.56	3.07	1842.1842

On the basis of the values obtained, the corresponding diagrams describing the operation of the hydraulic dissipative system, presented in Table 2, were made.

Table 2. The result values diagrams



4. Conclusion.

A hydraulic device is presented as a bridge protection system against the effects of earthquakes dynamic actions.

This device can perform energy dissipation when it is mounted to the insulated structure, while damping the translational movement of the superstructure relative to the foundation during the earthquake.

It is a device with a nonlinear principle of operation, having as working parameters the piston force and the piston rod displacement velocity.

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