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CHARACTERISTICS OF THE DISSIPATIVE HYDRAULIC JOINTS

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ABSTRACT

This paper analyses the theoretical and experimental characteristics of the hydraulic energy dissipaters used as dissipative joints for the mechanical structures subject to earthquakes, and vibrations. The paper allows the understanding of the dynamic behaviour of the dissipative joints which represent particular cases for the rheonomic and nonholonomic constraints.

KEYWORDS: Hydraulic energy dissipater, Shocks, Dissipative joints dynamic behavior, Shocks, Rheonomic and nonholonomic constraints

1. INTRODUCTION

In the field of protecting or insulating the man-made structures and the human beings against the effects of shocks, vibrations and earthquakes, there are facts well known at present, and yet research is done at national and international level.

The earthquake energy is transmitted from the ground to the building, on a specific range of frequencies (speeds), on certain directions and with certain intensities and act on the buildings or on other man made structures through stress induced by the inertial forces in the building's resistance structure. The bigger and more rigid a building is the bigger the effects induced by the seismic stress are and greater the damages made by dynamic stress will be.

They are also known methods of reducing the effects of earthquakes on buildings using dynamic absorbers placed on the building, of linear or pendular type, which have the role to reduce the linear deformations that might affect the superior part of the buildings.

In the case of shock and vibrations generating machinery and equipments, the phenomenon is inverted because some of the energy of the technological shocks and vibrations is transmitted from the equipment to the environment generating undesired effects.

There are also methods to insulate or absorb the technological shocks or vibrations made on the same principles.

There are such researches directed towards the study of complex absorbing structures for the effects of the earthquakes, shocks and vibrations. These absorbers are of viscous-elastic type, being made of rubber or composite materials. Other systems relay on complex buildings or foundations positioning systems on viscous environments (clay, rubber plates, carbon fibers, etc) or even on water.

Recent researches are in progress in Europe, as ECOLEADER programme is, since 2001, programme developed by universitary consortium formed by the University of Patras (Greece), University of Rome 3 (Italy), University of Pescara (Italy), University of Ancona (Italy) and industrial companies such as FIP Industriale (Italy) and TARK (Great Britain).

The results of this R&D programme show that the research in the field of annihilating the effects of these dynamic phenomena are still of actuality and may bring important benefits.

This article refers to the seismic energy dissipaters made of hydrostatic equipments which are capable to destroy the energy of the earthquake, shock or vibration for various frequencies, dissipaters that connect the material object subjected to the dynamic phenomenon to the base.

Thus, the energy of the earthquake transmitted to the building or the impact of shocks and vibrations generating equipment towards the environment will be lower, while the energy dissipated by the hydrostatic system will be larger. [5], [6], [7].

2. THE DISSIPATIVE HYDRAULIC CONNECTION

The hydraulic dissipater is constructed as a cylinder (1) with two chambers separated by a piston (2), chambers filled with a viscous environment (synthetic oil, silicon oil, particles in suspension, liquid metals etc.).

The piston is connected to a bar (3) and a compensation tube that crosses the two chambers on either side of the piston.

A third chamber (4) is situated inside the compensation tube and has the role of compensating the dilatation / contraction of the viscous environment under thermal effect.

The dissipater’s bar is connected at the base of the construction (I) and the body at the foundation of the construction (II) with plane or spatial joints (5).

The device works reversibly to the alternative traction and compression movements and the dynamic behaviour depends on the instantaneous frequency (speed) of the excitation generated by the earthquake, mechanical shock or vibration. (fig. 1).

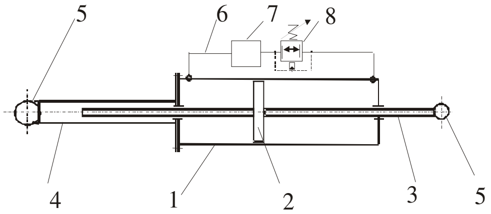

Fig. 1. Construction of the hydraulic energy dissipater

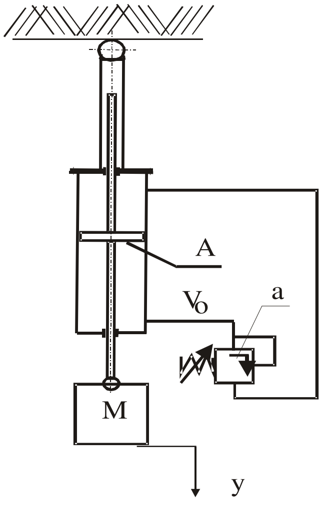

Fig. 2 Dissipater’s calculation dimensions and symbols

This action is generated by a system of pressure adjusting equipments (6), (7), (8) (called energetic regulators) created for various dissipation areas, these equipments being placed outside the dissipater.

An electronic monitoring system of the earthquake and technological shock or vibration commands the opening or closing of one or more regulators, according to the frequency and intensity of the movement, which leads to various stages of dissipation.

The symbols used for the dissipater’s scheme and necessary connections are presented in fig. 2.

3. THE CINEMATIC CHARACTERISTIC AND THE EXPERIMENTAL DYNAMIC OF THE DISSIPATER

The experimental characteristic is formed by the law of the variation of the dissipater’s piston’s momentary run (2) and the momentary resistance force of the regulator (8) inside the cylinder’s chambers (1).

The shape of this experimental characteristic is presented in fig. 3.

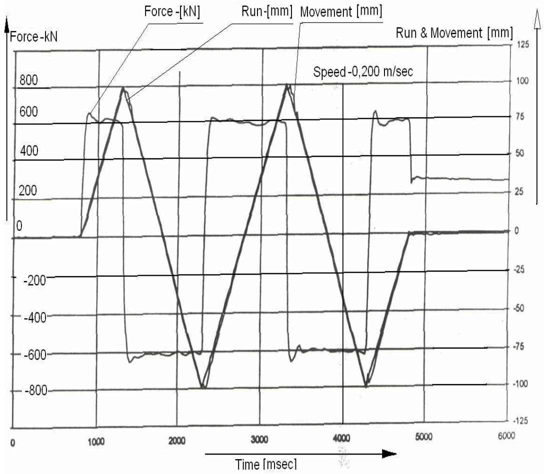

Fig. 3 The dynamic characteristic of the energy dissipater

The dynamic characteristic has been presented experimentally by recording the electric signal produced by an inductive movement translator, connected in parallel with the dissipater and a force translator serially connected to the dissipater. The movement of the ensemble was produced by a vertical press of 2000 kN.

The experimental cinematic characteristic is obtained by the variation of the dissipater’s run as a function of time while the dynamic characteristic is formed by the law of the variation of the resisting force in the system as a function of time. [6, 7].

4. THE THEORETICAL CINEMATIC AND DYNAMIC CHARACTERISTIC OF THE DISSIPATER

The theoretical dynamic characteristic of the energy dissipater has the following expression:

$$F(t)=\begin{cases}=A.p(t)\_ptr.\_t\in(0,\tau]\cup(3\tau,5\tau]\cup.....(\ ]\\=-A.p(t)\_ptr.\_t\in(\tau,3\tau]\cup(5\tau,7\tau]\cup..(\ ]\end{cases}; \quad (1)$$

The theoretical cinematic characteristic of the energy dissipater is given by the variation law of the dissipater’s run, as a function of time, according to the following mathematical expression:

$$y(t)=\begin{cases}v_0t,\_for\_t\in(0,\tau]\\2y_0-v_0t,\_for\_t\in(\tau,3\tau]\cup(5\tau,7\tau]\\\qquad\cup....((2k+1)\tau,(2k+3)\tau]\\v_0t-4y_0,\_for\_t\in(3\tau,5\tau]\cup(7\tau,9\tau]\end{cases}; \quad (2)$$

where:

$y_0=v_0\tau$, represents the maximal run of the dissipater,

v_0 – the movement speed of the dissipater’s piston,

τ – the dissipater’s time rate.

The theoretical characteristics are presented in fig.4.

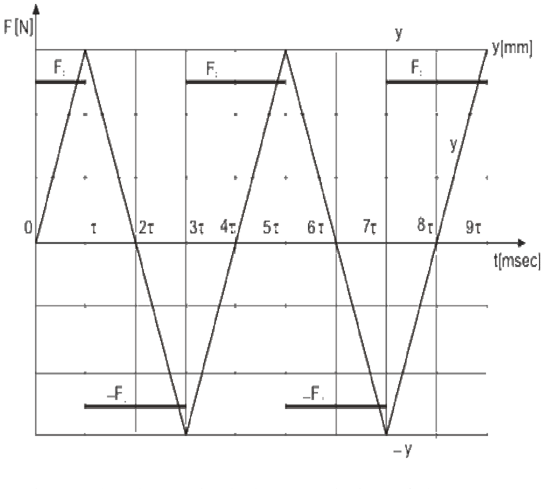

Fig. 4 The theoretical characteristics of the energy dissipater

5. THE THEORETICAL DYNAMIC MODEL OF THE DISSIPATER

The dynamic model of the energy dissipater is given by the flow equation of the hydraulic agent moved from a chamber to another during the run of the dissipater’s piston and by the equation of the forces applied to the piston (d’Alembert principle).

The dynamic model [2] is described by the equations:

$$\begin{aligned}&\frac{dy}{dt}=\frac{D}{A}\sqrt{p^3}-\frac{H}{A}\sqrt{p}+\frac{V_o}{A.E}\frac{dp}{dt}\\&\frac{d^2y}{dt^2}+\frac{C}{M}\frac{dy}{dt}+\frac{K}{M}y=\frac{g}{10}-\frac{A}{M}p\end{aligned} ; \quad (3)$$

where:

$$D=\frac{\pi^2.d^3}{4.k_r}\sqrt{\frac{2}{\xi.\rho}} \text{ and } H=\pi.d.\delta\sqrt{\frac{2}{\xi.\rho}}$$

are the dissipater’s constants.

6. THE NUMERICAL DYNAMIC MODEL OF THE DISSIPATER

For the numeric case of the following values:

K_r=104 daN/cm,
d=0,45 cm,
$\rho=0,0009$ kg/cm^3,
$\xi=1,8$,
A=115,4 cm^2,
V_o=3460 cm^3,
E=16900 daN/cm^2,
M=60000 kg,
g=9,81 m/s^2,
$\delta=0,9$ cm,
K=7...20 daN/cm,
C=0,07…1,5 daNs/cm,
p_{max}=700 bar, p∈ [0, pmax],
y [cm],

we get – by numerical integration – diagrams as those in fig. 5a and fig. 5b.

7. CONCLUSIONS

If we compare the movement characteristic y=y(t), fig.5.a, obtained from the theoretical model with the real one obtained experimentally, fig. 3 , we may notice that the two characteristics are relatively close to the purely theoretical one obtained and presented in fig.4.

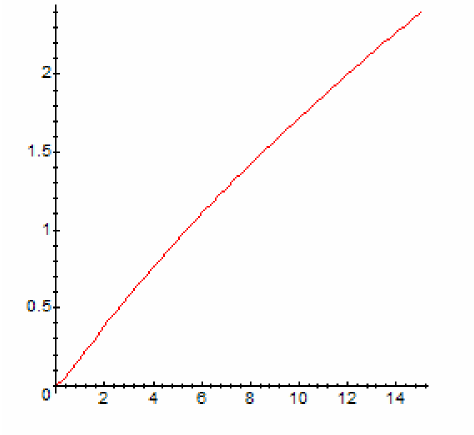

Fig. 5a Variation of y=y(t)

This varies almost linearly with time, as it was already specified in the purely theoretical characteristic.

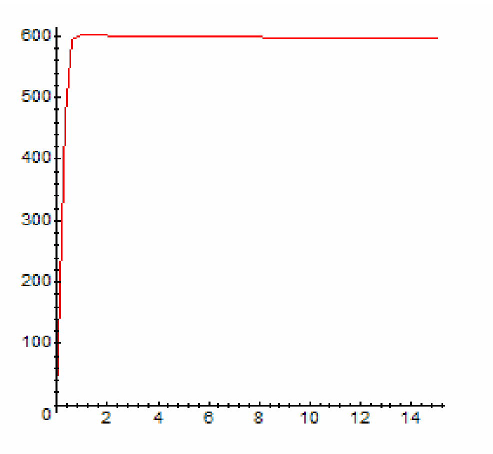

Fig. 5b Variation of F= F(t)

If we compare the force characteristic F=F(t), fig. 5.b, obtained on the theoretical model with the experimental characteristic from fig. 3, we notice that after exhausting the transitorial phase the force (and also the pressure) is relatively constant in time, as specified in the purely theoretical characteristic from fig. 4.

The two variables of the theoretical model, movement *y* and pressure *p*, respectively force F, where F=A.p, are obtained by integrating the non linear system (3).

The model serves for the study of the dynamic behaviour of the hydraulic dissipaters which are **rheonomic** and **nonholonomic** links components of level I, for the various rigid bodies subject to such mechanical connections (buildings, bridges, industrial buildings' structures etc.).

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