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Dynamic Behavior of a Friction Pendulum with Elastomeric Layer

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Transient dynamic characteristics of a friction pendulum can be determined using experimental ways. Nowadays, numerical simulation techniques allow obtaining these characteristics using mathematical models. The express advantage is represented by almost unlimited possibilities to extract and quantified in the regime of "post processing" regarding the results. In terms of efficiency this means increased performance regarding the research and product development.

Keywords: *analysis, finite element method, transient*

1. Introduction

Friction pendulum using a sliding surface generated by polynomial functions allows a precise control of motion and consequently of the dissipated energy, by using three parameters: one defined by the friction coefficient, the other two defining the polynomial surface. This type of friction pendulums are recently introduced in literature, [1]-[3], where their behavior is in some way described, but is mentioned that they are less abiding than the spherical or cylindrical friction pendulums. This happens because the polynomial functions induce a variable curvature to the sliding surface, generating a gap between the slider and the sliding surface. Therefore it is necessary to introduce an elastomeric element reinforced with a flexible metallic sole between the slider and the sliding surface. The paper present a FEM analysis performed on a such type of base isolator.

2. Transient structural analysis

By using the transient finite element analysis, can be determined the effects of changes made to parameters governing the quantitative control of energy dissipation, obtaining cyclic type results as: lateral acceleration, speed in different directions of interest, transitional reactions forces acting on the moving parts of the friction pendulum.

The kinetic energy of mobile elements is calculated dynamically in relation with interval of time when movement takes place. The friction coefficient constitutes one of the control variables of dissipated energy for the case considered in numerical analysis it is 0.02. Next, using comparison will be presented numerical results of "transient structural".

Figure 1. Friction pendulum at start possition for time interval t=0 [s]

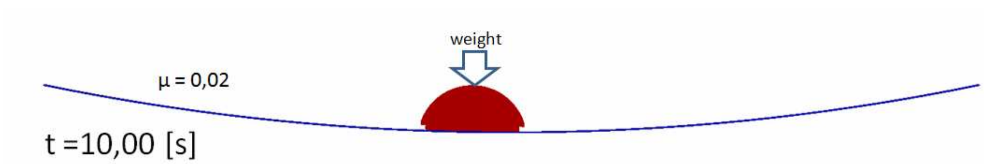


Figure 2. Friction pendulum in rest position after the stroke cycle and dissipation of kinetic energy for the entire time interval t=10 [s].

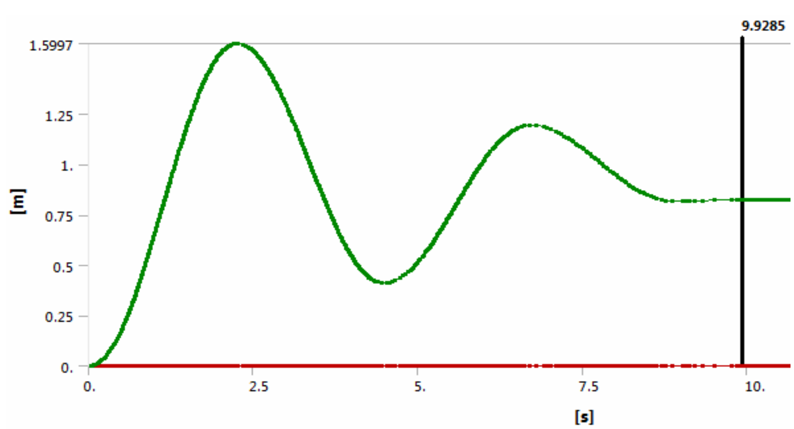


Figure 3. Mobile elements (pivot assembly) dispalcement cyclogram; μ = 0.02.

Regarding figure 3 the total slide curve lenght is about 1.6 [m] between center of mobile assembly, for the first cycle and then this variation is attenuated until the mobile assembly will be stop in position represented in figure 2.

Velocity variations can be seen in the figure 4, where the maximum value was obtained after first descent movement and has a value of 1.1292 [m/s].

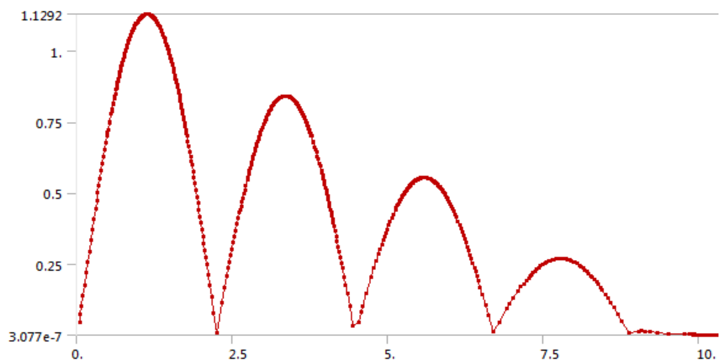


Figure 4. Mobile elements (pivot assembly) velocity cyclogram (velocity [m/s] vs. time [s]); μ = 0.02

For acceleration cyclogram, figure 5, we can observe that the maximum value is obtained immediately after adhesion of mobile assembly is defeated.

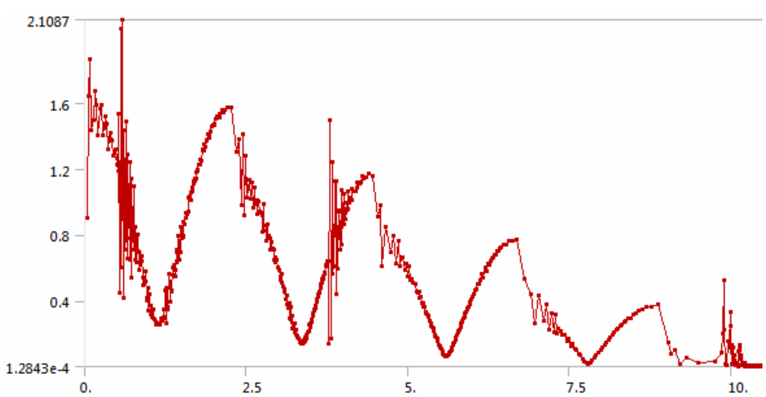


Figure 5. Mobile elements (pivot assembly) acceleration cyclogram (acceleration [m/s^2] vs. time [s]); μ = 0.02.

The maximum value of kinetic energy is about 72.683 [J] in perfectly concordance with weight of considered mobile assembly.

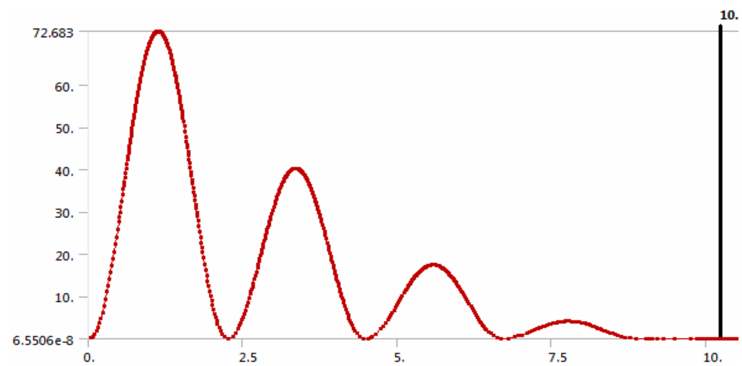
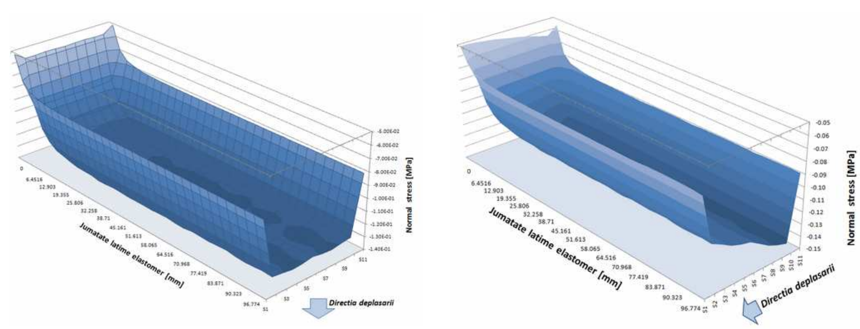


Figure 6. Mobile elements (pivot assembly) kinetic energy cyclogram (energy [J] vs. time [s]); μ = 0,02.

Normal stress distribution inside of elastomeric layer for different time interval is represented in figure 7 for an half of elastomer. For static phase where the mobile assembly is only pressed the variation of stress is almost uniform. When the horizontal movement is present the stress distribution is slightly different like in pictures with maximum value in the rear edge zone.

Cylindrical profile - 1 [s] Cylindrical profile - 2 [s]



a. b.

Figure 7. Normal stress distribution

3. Conclusion

Performed transient analysis proves the dynamic behavior of a friction pendulum excited by seismic oscillations. Acceleration diagram is in concordance with physical phenomena, which after a stop the curve have a linear decrease and then a resumption of curvature. This peculiarity occurs because the moving assembly must overcome temporary adhesion and for a short period of time the acceleration increase linear. The entire kinetic energy is dissipated after 4 cycles.

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