"The influence of the behaviour of the material on response of the structures to dynamic loads"

Luciano Nunziante(I)

Synopsis. In this paper are studied the dynamic responses to periodic loads of simple oscillators with various material behaviour. Moreover it is shown the influence of material behaviour on the dynamic response.

Introduction.

In many dynamical problems concerning structures impulsively loaded, is customary to assume a rigid plastic behaviour of the material. By many authors has been proved that the responses obtainable with such assumption are qualitatively and quantitatively very close to the real behaviour of the structures (I-2-3-4-5).

Also for structures subjected to alternate loading is very important to evaluate the influence of models assumed for the material on the dynamical responses, and to compare the real structural behaviours with the computed ones (6-7-8-9).

Problem's formulation.

In this paper is presented an attempt to obtain solution for the above problem. In particular have been studied the responses to periodic loads of a simple oscillator whith two degrees of freedom. The oscillator consists of two masses connected by a system of deformable hinges; the load is constituted by periodic horizontal ground accelerations of various shape (fig. I). The following models have been assumed for the material constituting the hinges:

Rigid-perfectly plastic
Elastic-perfectly plastic
Elastic-plastic hardening

Resonance frequencies have been avoided to study only the above stated problems.

The oscillators motion equations are as follows:

$$m_I(\ddot{\xi}(t)+\ddot{u}_I(t))=-F_I(t)+F_2(t) \qquad (I)$$

$$m_2(\ddot{\xi}(t)+\ddot{u}_1(t)+\ddot{u}_2(t))=-F_2(t) \qquad (2)$$

The set of differential equations has been integrated by Numerov numerical method. The reactive forces are given by

$$F(t)=k_E\cdot u(t)+c \qquad \text{(elastic range)} \qquad (3)$$

$$F(t)=k_H\cdot u(t)+Vo \qquad \text{(plastic hardening range)} \qquad (4)$$

(I) Associate Professor of Mathematical Analysis. Institute of "Scienza delle Costruzioni". Engineering faculty. University of Naples. Italy.

where the constants may assume the following values

$k_E=\infty$, $k_H=0$ (rigid-perfectly plastic) (5)

k_E=finite, $k_H= 0$ (elastic-perfectly plastic) (6)

k_E=finite, k_H=finite, $k_E > k_H$ (elastic-hardening) (7)

Description of the results.

Comparison of the responses of oscillators (5) and (7).

Rigid plastic oscillator's response to periodic loads is a periodic motion with the load frequence and the displacements have always the same sign(fig.2).

These numerical results agree perfectly with theoric previsious of previous works(7-8).

Also for very big values of the elastic modulus k_E, the elastic plastic oscillator exhibits responses qualitatively different from those of the rigid plastic oscillator, in that the displacements are bigger and of alternate sign. Moreover elastic deformability plays an important role with regard to safety of the structure; in fact periodic loads that produce plastic deformations in the rigid plastic oscillator, are not able to plasticize the elasto plastic oscillator.

This result is justified by the capability of the elastic plastic oscillator to accumulate the energy received from the external loads in the elastic range(elastic oscillation).

The energy dissipated by the rigid plastic oscillator is always much bigger than in the case of the elasto-plastic oscillator. So the differences in behaviour are very strong both from quantitative and qualitative point of view.

Comparison of the responses of oscillators (6) and (7).

The responses of the elasto plastic hardening oscillator are similar to that of the elasto plastic, but are characterized by a smaller maximal displacements.

As $k_H \rightarrow 0$ the elasto plastic response is approximated with continuity(fig.3).

The total plastic dissipated energy is an increasing function of the ratio k_E/k_H(fig.4). This function is practically constant if k_E is conveniently large.(fig.4).

From the previous considerations is apparent that the hardening has a damping effect in comparison with the perfect plasticity; this result confirms the anticipations of a previous work(8).

Conclusions.

The above results shows that the behawiour of the structural material plays an important role in the structural response to periodic load.

The responses of the structures with rigid plastic behawiour can be damper only by energy dissipation in plas=

tic motion.

The elastic deformability is very important for the safety of the structure, indeed in many cases the structure supports in elastic range the periodic load that allows to plasticize the rigid plastic structure having the same V_o of the previous.

But this advantage is practically not considerable abowe certain value of alastic deformability.

Moreover, the plastic hardening is another important cause of damping of dynamic response.

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fig 1

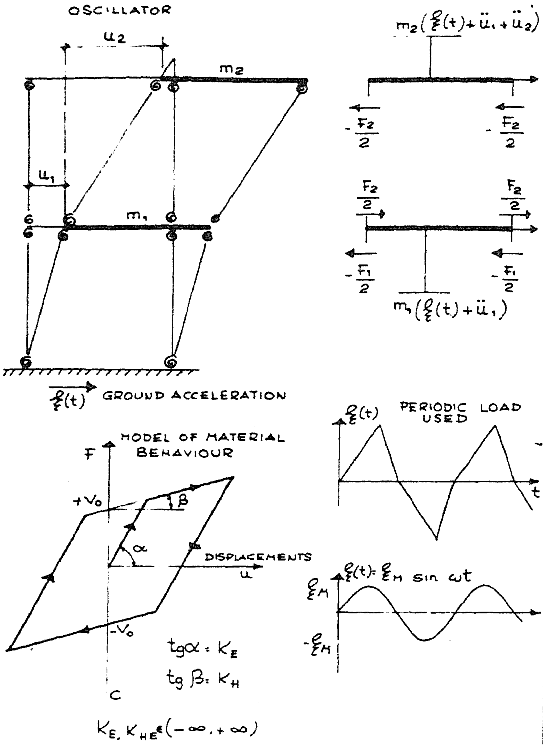


fig 2

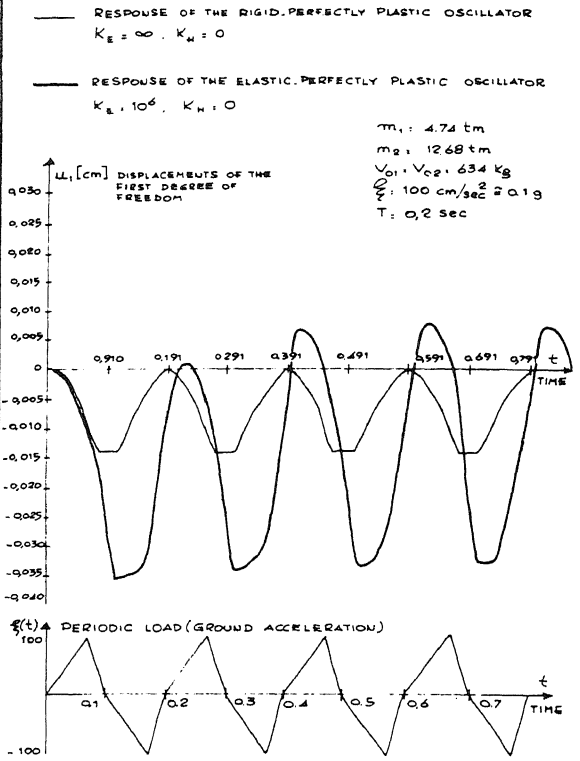


fig 3

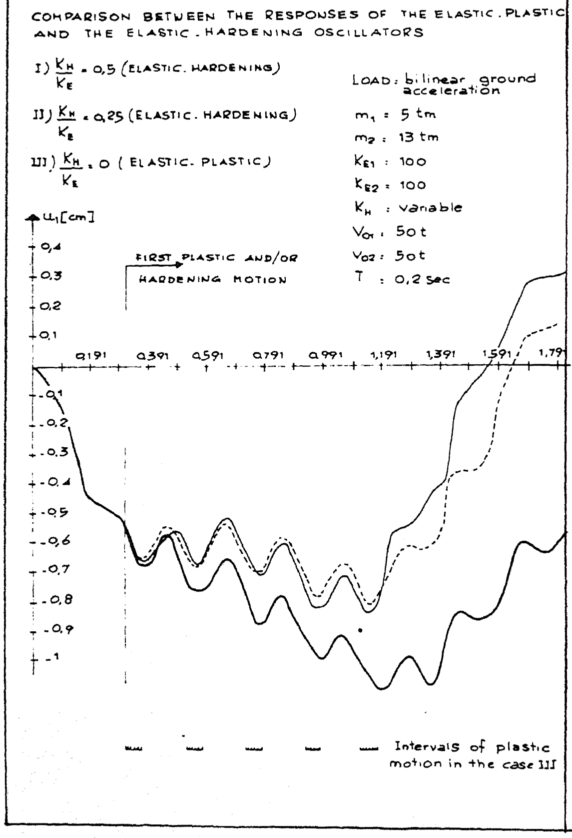
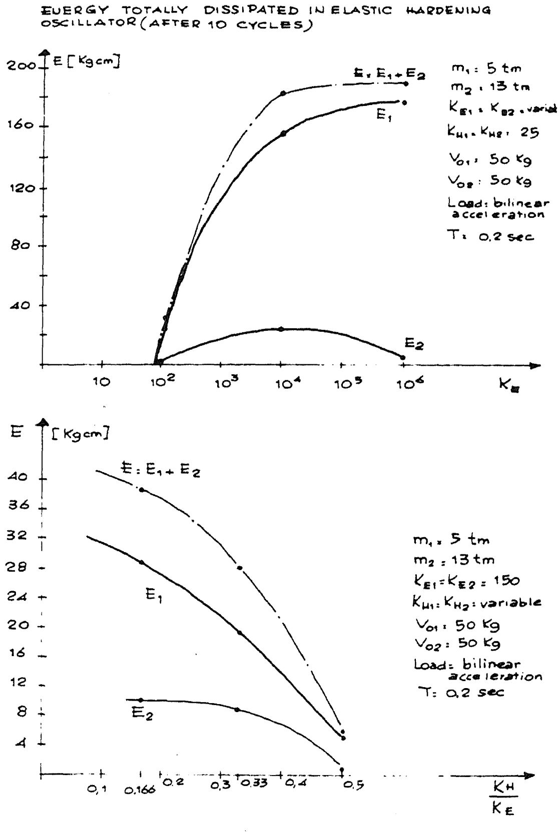

COMPARISON BETWEEN THE RESPONSES OF THE ELASTIC-PLASTIC AND THE ELASTIC-HARDENING OSCILLATORS

fig 4


ENERGY TOTALLY DISSIPATED IN ELASTIC HARDENING OSCILLATOR (AFTER 10 CYCLES)