THE APPLICATION OF MODEL IDENTIFICATION AND PARAMETER STUDY IN NONDESTRUCTIVE TESTING OF AN ELASTIC STACK

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INTRODUCTION

In 1965 J. W. Cooly and J. W. Tukey published their famous paper "The Calculation of Fourier Series by Computer". This allowed model identification and measurement technology to be developed to a new stage. After inputting stimulus and response signals, the whole model and physical parameters can be obtained from computer calculations.

MOBILITY IDENTIFICATION OF THE ELASTIC STACK

The integral can be seen as a simple spring system as shown in Figs. 1 and 2. Its mobility is:

$$H(w) = \frac{X(w)}{F(w)} = \frac{1}{K - w^2 m + jwc}. \tag{1}$$

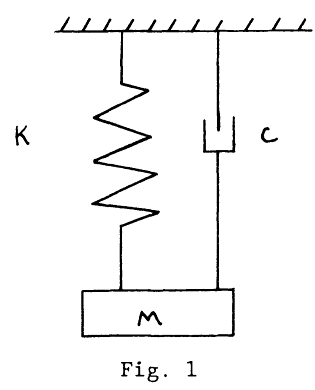

Fig. 1

Review of Progress in Quantitative Nondestructive Evaluation, Vol. 9
Edited by D.O. Thompson and D.E. Chimenti
Plenum Press, New York, 1990

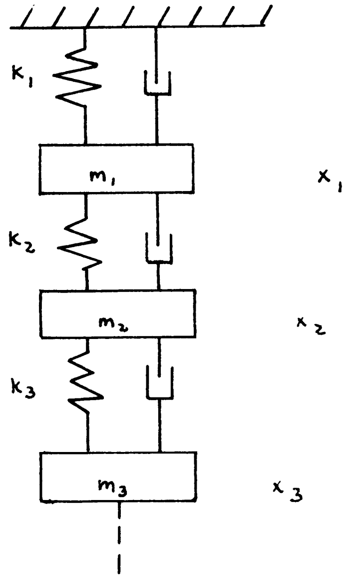

Fig. 2

When $w \rightarrow 0$ then: $H(w) = \frac{1}{K}$ will be the reciprocal of the elastic coefficient of the spring. If $w = \sqrt{K/m}$, then $H(w) = 1/Kg$, where $g = 2\overline{w}C/Cc$ is the attenuation coefficient, $Cc = 2mwn$, and $wn = \sqrt{\frac{K}{m}}$ $\overline{w} = w/wn$ is the dimensionless frequency. When $w \rightarrow \infty$ the equivalent m can be obtained, $H(w)|_{\infty} = 1/w^2m$. This means that we can get the different physical parameters of the stack from the amplitude-frequency feature.

If the piles diameter and quality have changed, it can be seen since the stack's a system made of several springs with different parameters. Thus,

$$m_1\ddot{x}_1 + (C_1 + C_2)\dot{x}_1 + C_2\dot{X}_2 + (k_1 + k_2)x_1 - k_2x_2 = f_1$$

$$m_2\ddot{x}_2 + (C_2 + C_3)\dot{x}_2 - C_2X_1 - C_3\dot{x}_3 + (k_2k3)x_2 - k_2x_1 - k_3x_3 = f_2 \tag{2}$$

which can be written in matrix form as:

$$(M)(\ddot{X}) + (C)(\dot{X}) + (k)(X) = (f) \tag{3}$$

The ith module model is:

$$(ki - wMi + jwci)qi = f_1 \tag{4}$$

in which $Ki = (\phi)_i^T(K)(\phi)_i$, general rigidity

$Mi = (\phi)_i^T(M)(\phi)_i$, general mass

$$Ci = (\phi)_i^T(C)(\phi)_i \quad \text{, general damping}$$

$$= \{(\phi)_1(\phi)_2\cdots(\phi)_n\}.$$

From (4) we find that the n unit's system is similar to the single but different in the model coordinate only.

MEASURING METHOD OF MODEL IDENTIFICATION

1. Put the measurement sensor on the top of the stack to measure the velocity and displacement. Make an arbitrary judgement of the tack to determine whether it is complete or broken into n sections. Set n module equation and conduct simultaneous calculations until its result agrees with the measurements.

2. Component Identification Method. The whole spectrum may be seen as an overlap of several spectra. A stimulus is made at point p and the measurement is taken at point L.

$$H_{pl}(w) = \sum_{l=i}^{n} \frac{\rho_{il}\rho_{pl}}{K_i(1-w_i^2)+2j\overline{w}_l} \tag{5}$$

For example, for a stack (L = 11.7m, Fig. 3) whose bottom is expanded, we obtain the spectrum shown in Fig. 4, which may be divided into two spectra. The average length diameter of the bottom part of this stack and the strength of concrete can be gotten from the overlap of these two spectra components.

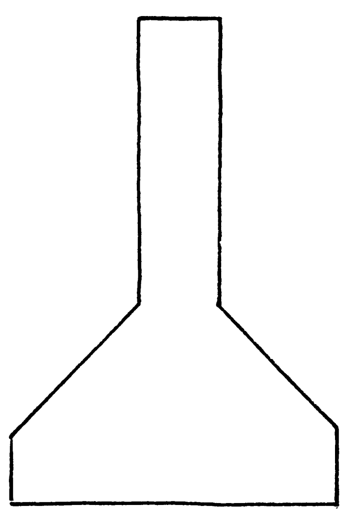

Fig. 3

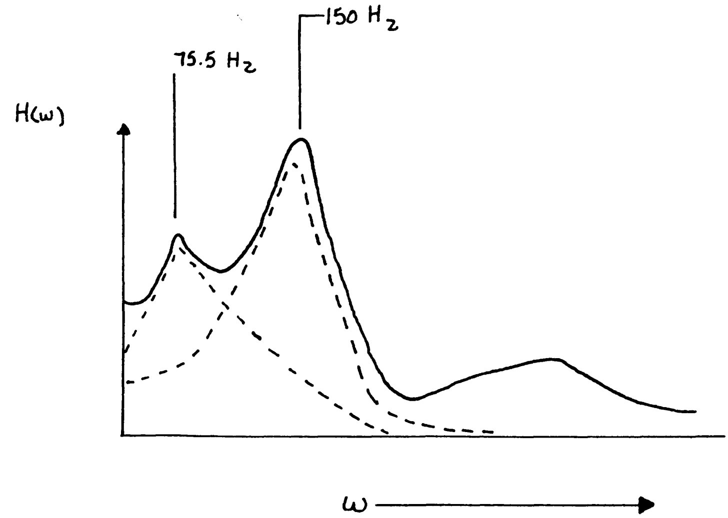

Fig. 4

SEISMIC SOURCE OF TRANSIENT MEASUREMENT

In the transient measurement of a stack, an impulse function with a wide spectrum is necessary. The electrohydraulic effect is the result of a very high pressure produced by high voltage discharge under water. The pressure is:

$$p = 10^{-3}\frac{1}{r}\left(\frac{CU^6}{L^2}\right)1/5 \tag{6}$$

Where r--distance between discharge electrode and measurement point (cm);
C--capacity of storage capacitors (uf);
L--loop inductance (H);
U--charge voltage (V).

When r = 30cm, C = 10 uf, L = 3.12 uH, U = 9000 V, the p will be 29.3 kg/cm^2. If the pressure is used to stimulate a pile whose spectrum is shown as Fig. 4 (d = 1.2m), the force produced by it will be 320T. The functional time $\tau = \pi\sqrt{LC} = 1.75\times10^{-5}$s. The narrower the width of pulse, the wider the spectrum will be. The frequency $f_m = 1/\tau vs 5.69\ x 104\ Hz$.

CONCLUSIONS

1. By using high voltage discharge under water, we can get a very good seismic source to measure elastic stacks.

2. Different parameters of the stack can be obtained from model identification, and it is not necessary to put measurement sensors on the bottom of stack.

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