HYBRID FAILURE TEST ON A STRUCTURAL MEMBER

by

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METHOD OF A TEST

A hybrid dynamical failure test on the following models was performed by a hybrid testing machine which is a combined system of a electro-hydraulic testing machine connected with an on-line analogue computer, for the purpose of evaluating the nonlinear properties of structures affected by a severe earthquake. (Fig. 1)

Models

The computer calculates a response of a structure to an input force using the restoring force R obtained by a electro-hydrodynamic machine and only the structural member which will fail during earthquakes is placed to the electro-hydro machine.

Fig. 2 explains how to replace a structure to this hybrid test system. Since only the beam column will fail due to earthquake in one mass system, the beam column is placed for the testing machine, on the other hand, for a structure supported by a pile foundation, the model of the pile foundation is to be tested at the electro-hydrodynamic machine. Two types of models were adopted for this hybrid test, the one is a column beam, another is a pile foundation as indicated in Fig. 2.

Test Machine

Details of test machine is shown as belows.

Maximum dynamic force	2 ton
Frequency range in linerarity	DC∼20 Hz
Maximum velocity	80 cm/sec
Maximum half amplitude	10 cm
On-line computer	Analog computer

Types of Input Forces

The following forces are applied to the models as an external force.

1) Sinusoidal wave (1, 3, 10 Hz)
2) Transient sinusoidal wave (1, 3, 10 Hz)
3) Pseudo earthquake wave (Transient band limited white noise)
4) Stationary band limited white noise

Among these forces, the author generates the transient wave by multiplying a transient envelop function g(t) as shown below with sinu-

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soidal or filtered noise function f(t).

$$g(t) = e^{-At} - e^{-Bt}$$

TEST RESULTS

Model I (Steel beam)

In this case, force ~ displacement relation is mostly of a soft spring type as shown in Photo. 1. Fig. 3 shows a structural non linear response to an earthquake type input and the restoring force characteristics at that time is indicated in Photo. 2.

In Fig. 3 the restoring force is not of similiar wave shape as the response, in other words, it is not proportional to the response.

And it is pointed out that in case of a transient input force, once the fracture starts on the structure, a plastic flow of the structural member occurs almost always on only one side, therefore, the restoring force doesn't trace so many hysteretic cycles, but only one or few.

Model II (Pile foundation)

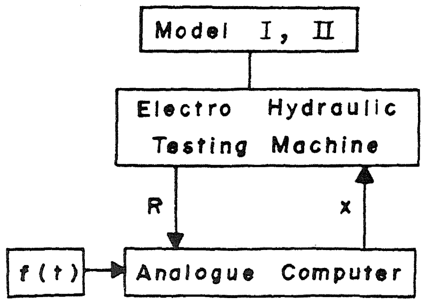
In this case, force ~ displacement relation is a kind of hard spring whose maximum restoring force traces a soft spring curve.

Photo. 3 shows a typical characteristics of restoring force of a pile embedded in dry sand. A strange figure in Photo. 4 is the characteristics of restoring force of the pile in case of sand with 13.6 percent of water content and since a gap between the pile and the sand happens during vibration, the restoring force is almost zero for the gap interval.

Photo. 5 shows the restoring force for the structural response in case of the dry sand and earthquake input force.

Fig. 4 is the results by the tests without a controlled computer, in other words, the direct application of the force upon the structural member.

It is for the transient sinusoidal force and moist sand (13.6 % water content).



$$\ddot{x} + 2hp\dot{x} + R = f(t)$$

Fig. I Diagram of Hybrid System

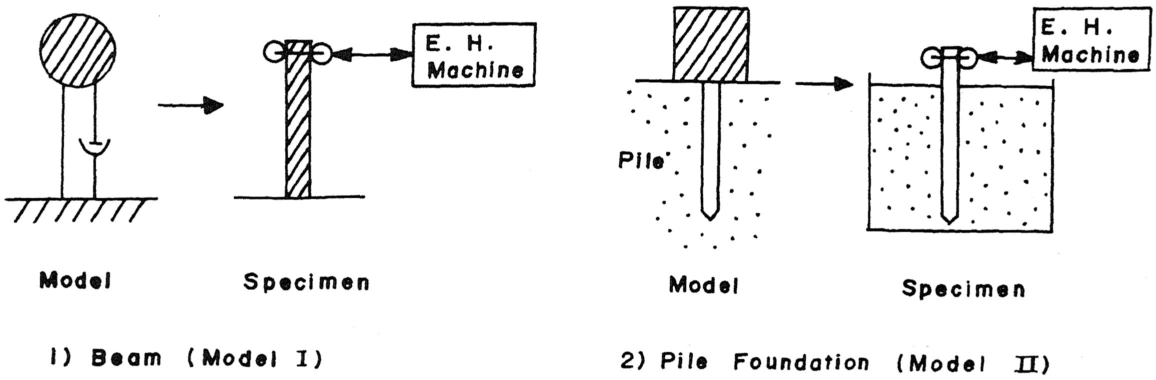


Fig. 2 Modelization for the Failure Test

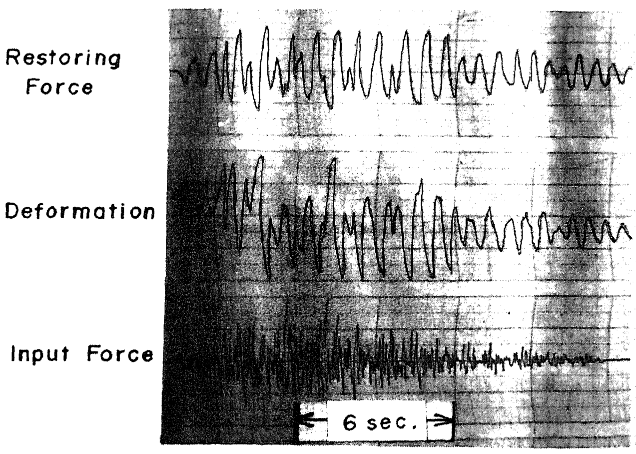


Fig. 3 Non Linear Response

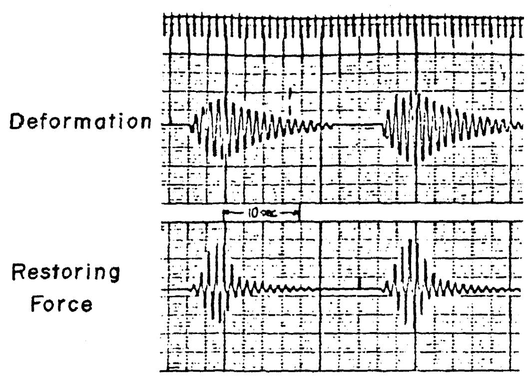


Fig. 4 Input : Transient Sine

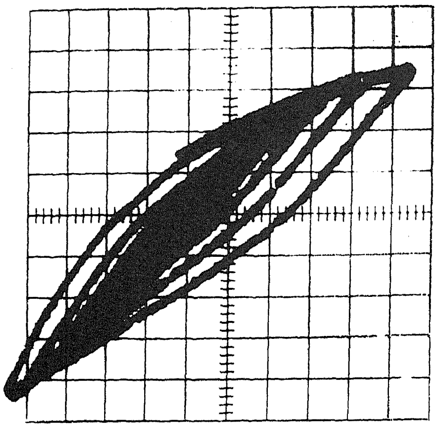


Photo. 1 Input : Sinusoidal

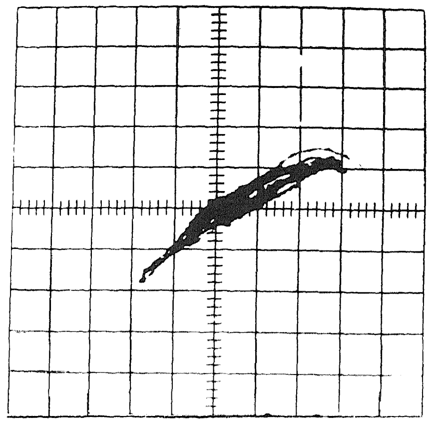


Photo. 2 Random Response

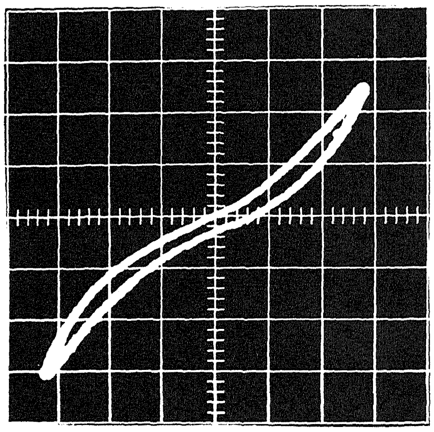


Photo. 3 Dry Sand, Sinusoidal Input

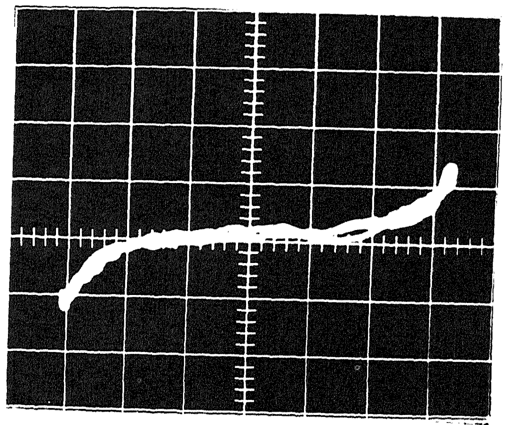


Photo. 4 Moist Sand (13.6%)

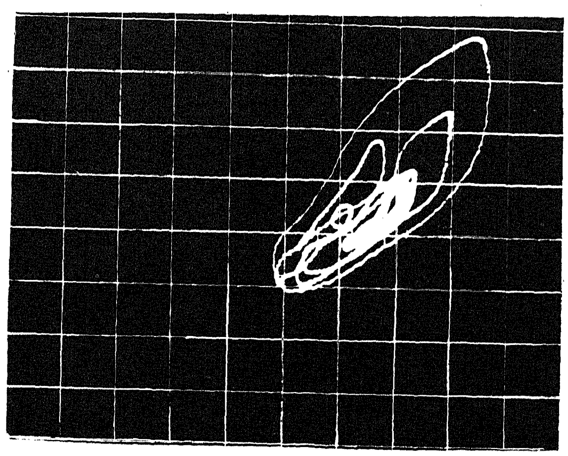


Photo. 5 During Structural Response