VIBRATION TEST OF A STRUCTURE SUPPORTED BY PILE FOUNDATION

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Synopsis; Soil-structure interaction problem has appeared before the foot-light when the effect of surrounding soil upon the foundation or the bearing capacity of soil during vibration became an important problem to be solved. To make clear such problems as above, the large size vibration table has been installed. In this preliminary report, the outline of the experiments and equipment was described, and problems of similitude was also described here.

(a)

(b)

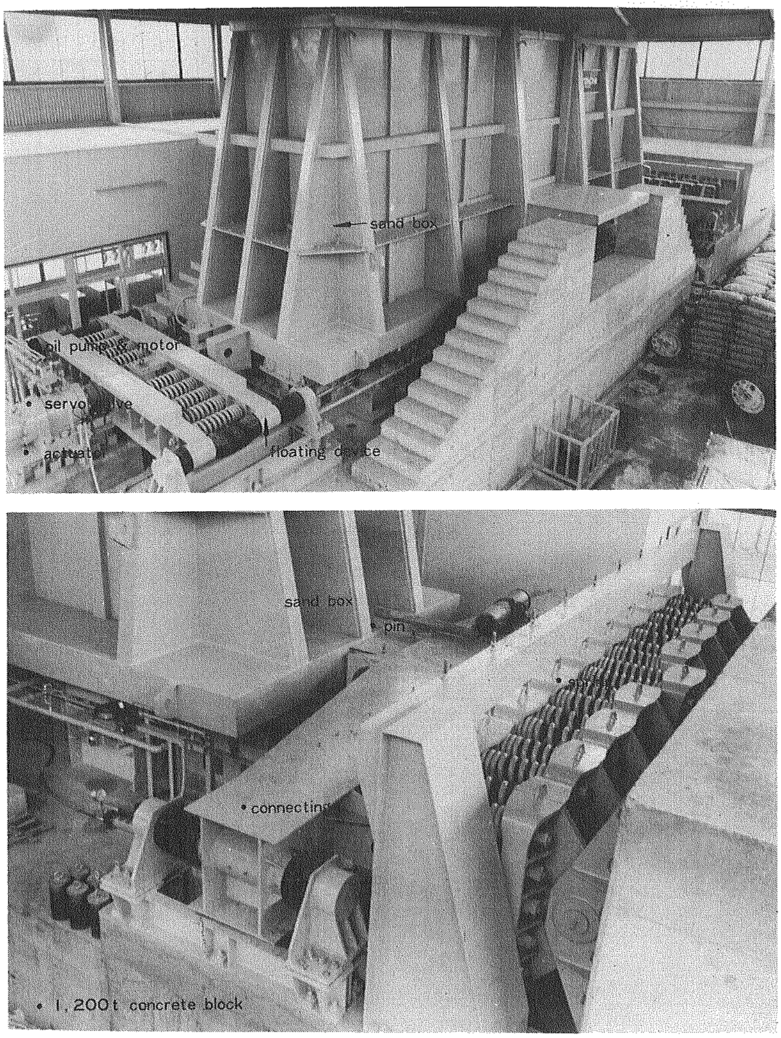

Photo. 1 Details of the Shaking Table.

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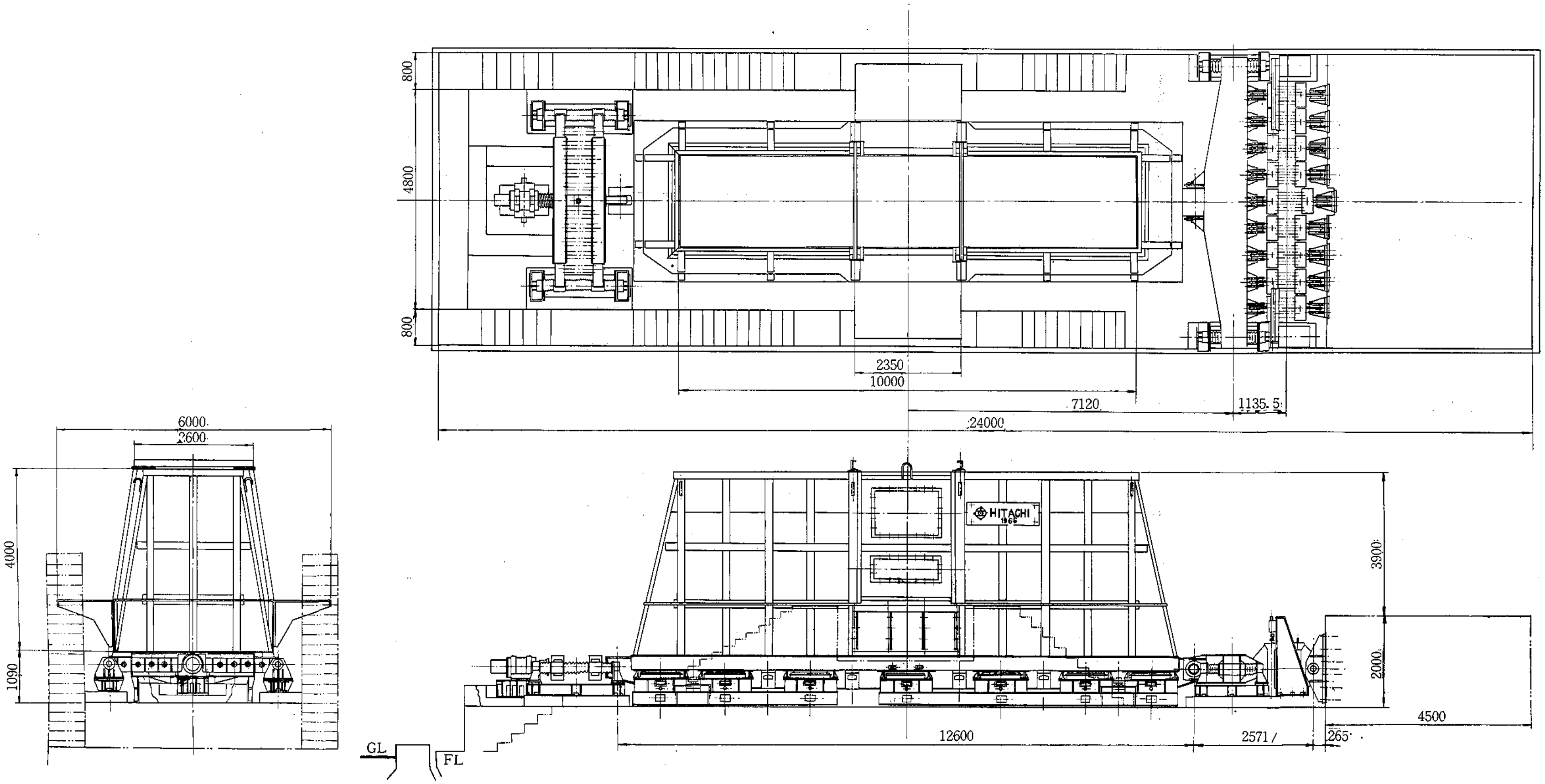

Unit: mm

Fig. 1 Large Size Shaking Table

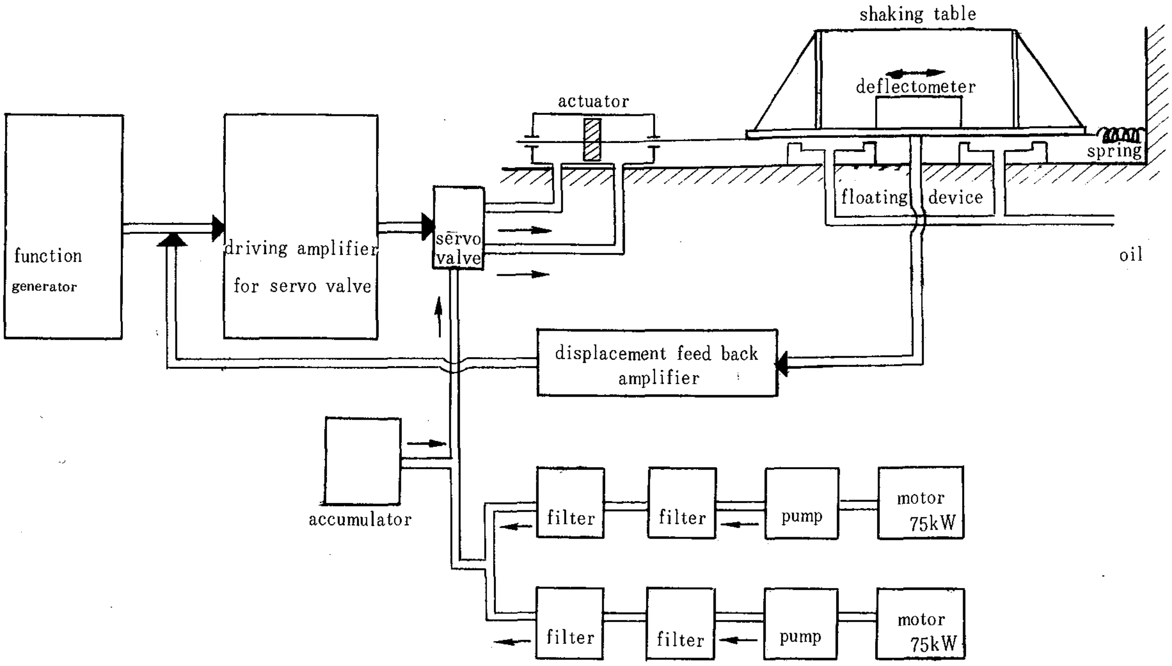

Fig. 2 Mechanism of Driving

1) Large size shaking table.

It is well-known that small size vibration table does not give us satisfactory results for the experimental studies on earthquake resistant properties of such soil structures as embankment and fill-type dam on soil-structure interaction problems, which will occur in case of surveying stability of foundations, and analyzing the behavior of underground structures and so on, because in vibration tests of small size, the similarity law between model and real system is not perfectly satisfied. Due to the reason mentioned above, the mammoth shaking table was planned and installed in Chiba Experiment Station of the Institute of Industrial Science, the University of Tokyo, in 1967.

In order to investigate vibrational characteristics of soil structures, foundations in soft ground and underground pipeline and so on, the big sand box was equipped and it is 10 m long, 4 m deep, and 2 m wide.

As middle parts of both side-walls parallel to the direction of exciting are able to be removed, such a long size model as that of bridge can be put to vibration transeversely.

The shaking table is moved in one horizontal direction with electro hydraulic servo system, which is driven by two oil pumps of 100 HP for each. The power of oil pump is not enough to move the sand box of 170 tons weight with desirable amplitude or acceleration. Then to get the enough emplitude of the table for testing the non-linearity of soil layer and to get an accurate sinusoidal waves in the vibration of the table, resonating phenomenon of the table and detachable spring system are utilized. The number of the detachable spring is 9. In order to minimize the friction between shaking table and its support, floating device by oil pressure is used. The mechanism of driving is illustrated in Fig. 2, and the main properties of the shaking table are as follows.

Period; 0.1 sec ~ 1.0 sec
Maximum amplitue; ±100 mm
Maximum acceleration; 400 cm/sec/sec

Here, the writer wants to describe the base structure of the shaking table. The base structure consists of 3 parts, that is, 1200 t concrete block, 54 isolation rubber blocks reinforced by steel plates, and foundation concrete slab. By this, harmful tremor does not propagate out through the base foundation in operation and no one can feel any ground vibration outside the shaking table house.

The mammoth shaking table is made by HITACHI Ltd., under supervising of the Laboratory of Earthquake Resistant Structures, the Institute of Industrial Science. (See Photo. 1. and Fig. 1 and 2)

2) Model vibration tests of liquid gas tank

Liquid gas tanks will be constructed on southern part of Yokohama where the soft silty clay layer 15 m in thickness covers the little hard mud-stone layer, so-called Dotan in Japan. The 21,440 tons tank, including liquid gas weight, is designed to be supported by 349 steel piles, and the pile is 50 cm in diameter, and 12.7 mm in thickness, and the treatment works of soft silty clay layer are now under construction.

In this design, due to low temperature of natural liquid gas (about-160°C), the bed slab of the tank must be isolated up from the ground surface, and so the soil pressure can not at all be expected to resist the horizontal seismic force applied to the gas tank.

In order to examine aseismicity of the liquid gas tanks, model vibration test was done.

As a fundamental concept, similarity about acceleration is decided to be one, because gravitational acceleration is invariable. To fully satisfy the similarity law, scale in length must be small. In this case, the scale of the model is 1:5, and the scale in weight is 1:123, and the other physical quantitites are automatically decided by above three factors, that is, acceleration, length and weight. Relations between physical properties of the model and those of the prototype are shown in Table-1.

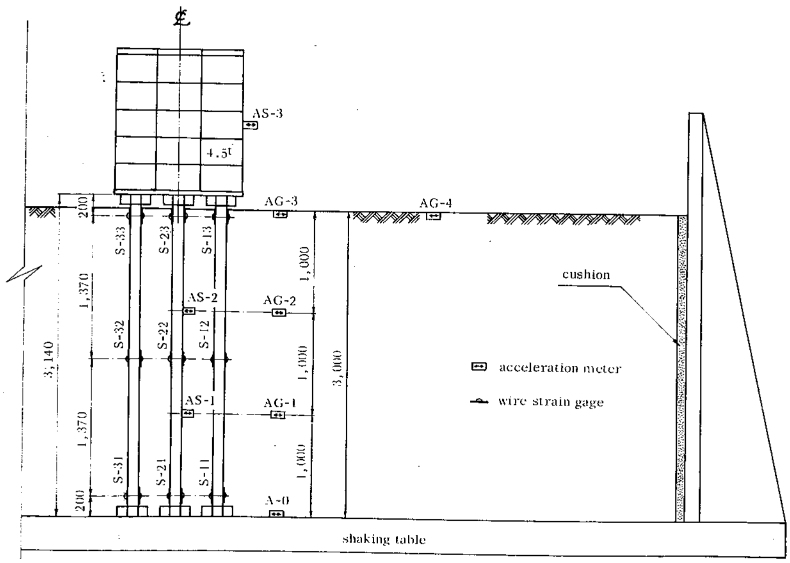

Fig. 3 Model and Position of Measurement

Table-1

Physical Property	Dimension	Scale
Acceleration	LT^{-2}	1
Length, Diameter	L	1/5
Weight, Force	MLT^{-2}	1/123
Stress, Cohesion	$ML^{-1}T^{-2}$	about 1/5
Flexural rigidity	$ML^{3}T^{-2}$	1/123 x 25
Angle of repose	none	1
Specific gravity	$ML^{-2}T^{-2}$	about 1
Time	T	$1/\sqrt{5}$

The model of soft ground is made from the mixture of both cinder sand and isolation oil, whose mixing ratio is 8:2. The cohesion of the model ground is about one-fifth of that of the prototype which is measured by vane-test in the field, and the similarity about cohesion is satisfied by adoption of the mixing ratio mentioned above.

The experiment was done changing step by step the frequency as well as the amplitude of the shaking table, on the partial model with 9 alluminum piles. (see Fig. 3) Results obtained are shown in Fig. 4 and 5.

As the experimental research has not yet finished, here only tentative conclusions will be described as follows.

a) Fundamental period of the model is 0.6 sec, and that of the prototype is estimated to be 1.3 sec, which is a little longer than the theoretical one.

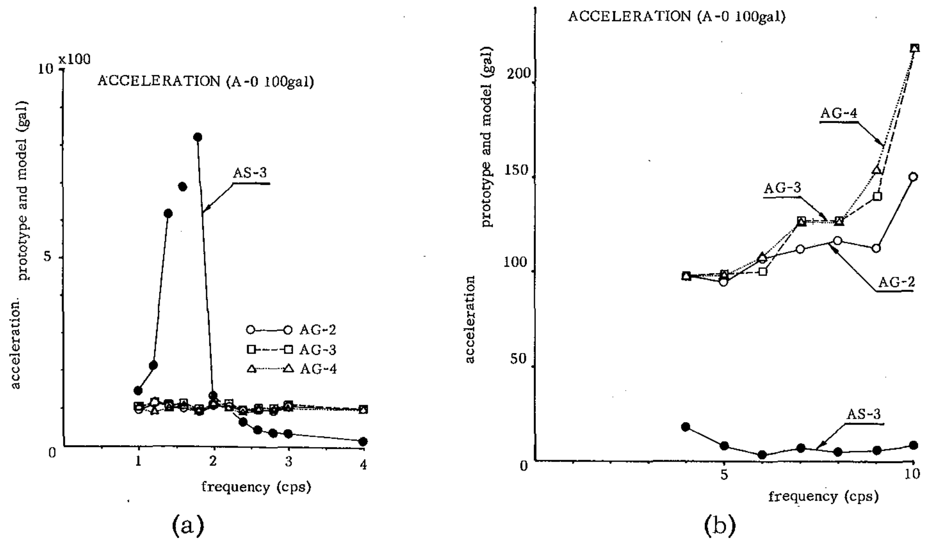

Fig. 4 Acceleration in the Ground