INVESTIGATION OF SOIL BUILDING INTERACTION SYSTEM
ON LARGE MODELS WITH PRECAST PANEL

by

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INTRODUCTION

In order to improve the reliability of earthquake response analysis of a building, it is required to establish more realistic dynamic model of the building including soil-structure interaction effects and to select the probable ground motion input more accurately. This paper describes the results of experimental and related analytical studies carried out on a simple soil-building system and the evaluation of the validity and reliablity of proposed practical dynamic models including interaction effects.

OUTLINE OF THE TEST MODELS AND EXPERIMENTS

Two test models, one on a mat foundation and the other on a pile foundation, are of one story concrete covered steel frame with precast concrete panel, the dimension being 4.0m x 7.0m both in plan and section as shown in Fig. 1. The models were constructed on a relatively simple natural soil layer. The test results of the superstructure with precast concrete panel fixed on a rigid test floor were described in a previous paper[1)]. The subsoil below the models consists of three layers; the Kanto loam layer, clay layer and gravel layer in order from the surface. The soil profile, penetration test result (N-value) and the frequency characteristics are shown in Figs. 2 and 3.

Various kinds of experiments were carried out on these models such as horizontal alternative static loading tests,free and forced vibration tests, seismic exploration test, earthquake observations and microtremor measurement. The location of seismometers and the aspect of the experiment are shown in Figs. 1 and 4.

EXPERIMENTAL AND ANALYTICAL RESULTS

Analytical studies were performed using various methods such as the finite element method, the one-dimensional wave propagation theory, etc.

The load-deflection curves and the resonance curves at the top of the models are shown in Figs. 5 and 6, and static and dynamic rigidities, natural periods, damping coefficients and mode shapes are tabulated in Table 1. It was found that the natural periods were 0.126 to 0.16 sec. for mat foundation and 0.17 to 0.23 sec. for pile foundation getting larger values as the deflection amplitude increases about from 0.1mm to 10.0mm; among total lateral displacement at the top of the superstructure, the contribution of the rocking for mat foundation amounted for about 35 to 50% and that of the swaying for pile foundation amounted for about 50 to 60% in both static and dynamic tests; and that the damping coefficients were

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about 5 to 15% for mat foundation and 3 to 8% for pile foundation depending on the magnitude of deformation imposed in the model.

The fourier spectra obtained from earthquake motions permit to determine the dynamic characteristics of the soil-building system taking the spectral ratios between two observation points (See Fig. 7). The natural periods thus obtained agree fairly well with those obtained from forced vibration test results.

According to the results of forced vibration test, the accelerograms at -5m level were considerably large compared with those at -15m level for the resonance period. Their ratio was less than 1/10. Therefore, it is considered to be satisfactory to deal with the interaction system above -15m level as the dynamic model in this study.

Among the analytical models used in this study, a model, which consists of finite elements and a mass-spring system representing soil layer and the superstructure, respectively, is illustrated in Fig. 8. Using this model it was found that disagreement existed between experimental and analytical results, especially on the rocking and swaying components, despite of utilizing the reasonable values as the model constants. Therefore, it was attempted to modify the model adjusting the length of contact area between soil and superstructure, the rigidity of first soil layer, cross section area, etc. for mat foundation or inertia moment and cross section area of pile for pile foundation (See Fig. 9). After the modification,agreement becomes much better. Fig. 10 show fourier spectral densities of the accelerogram at the top of the test models for observed (solid-line) and computed (dotted line) ones. They are fairly close to each other within the period range of 0.1 to 0.3 sec.

CONCLUDING REMARKS

From the results of experimental and analytical studies on the large models of steel frame with precast panel it is pointed out that; (1) the natural periods increase about 35% with the increase of deflection amplitude about 100 times from 0.1mm to 10.0mm; (2) the underground level below the superstructure on which the influence of its vibration becomes negrigibly small, was found to be 15m below the surface which is about 6 times the height of the superstructure; and (3) by making some modifications it is possible to determine a realistic model including interaction effects using finite elements and the spring-mass system.

Finally, authors wish to express their thanks to Prof. H.Umemura, University of Tokyo, and the staffs of his laboratory, who have given valuable guidance and help during the studies.

REFERENCE

1) R.Tamura, et al. "A Vibration Test of a Large Model Steel Frame with Precast Concrete Panel until Failure, IV W.C.E.E., 1968

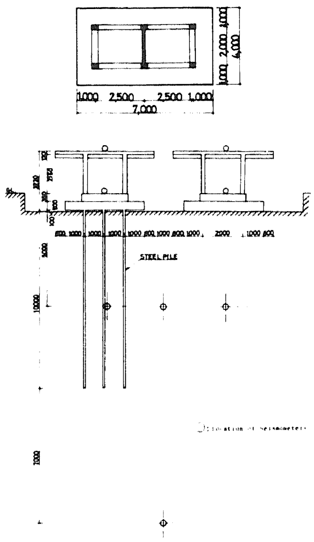

Fig.1 Plan and Section

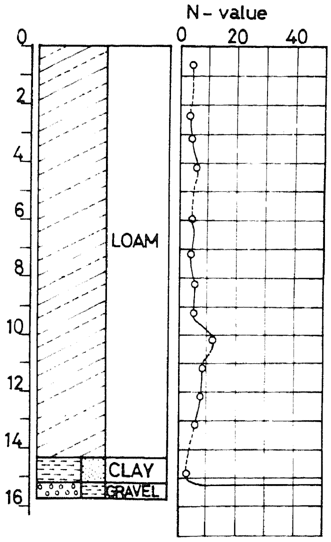

Fig.2 Soil Profile

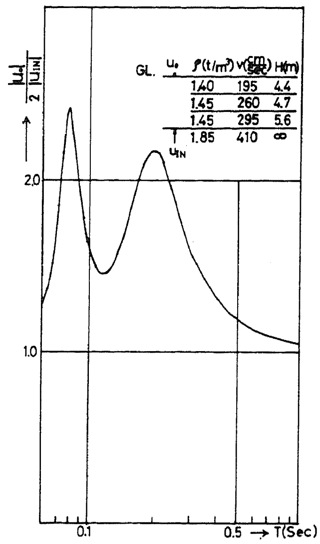

Fig.3 Frequency Charac.

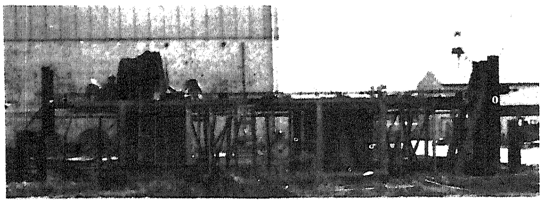

Fig.4 Aspect of Experiments

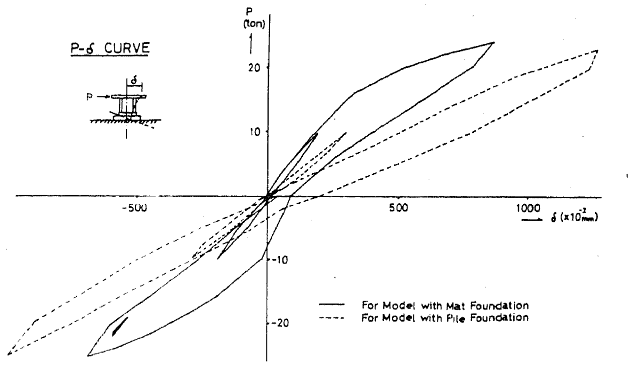

Fig.5 Load-deflenction Curves

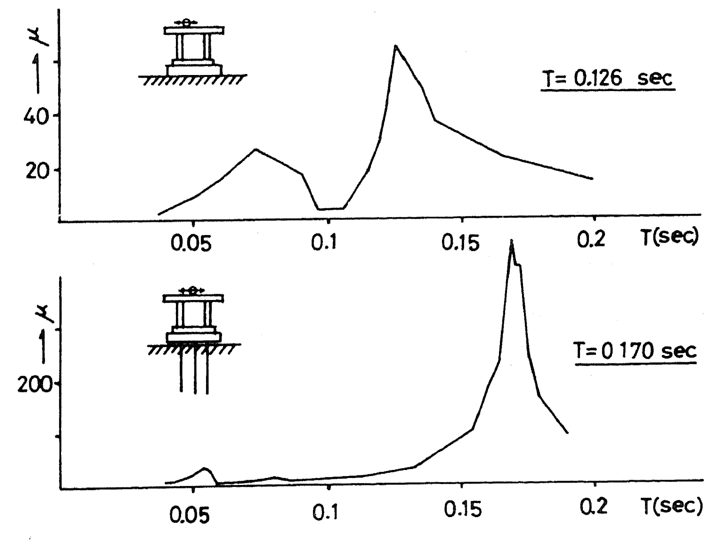

Fig.6 Resonance Curves

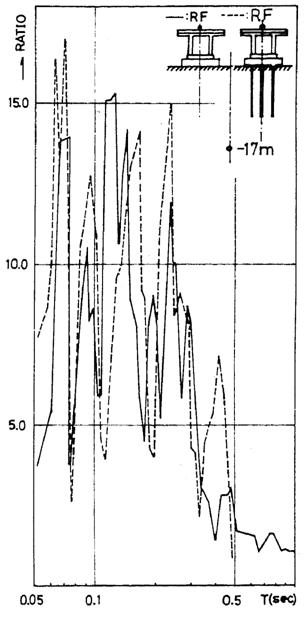

Fig.7 Spectal Ratio

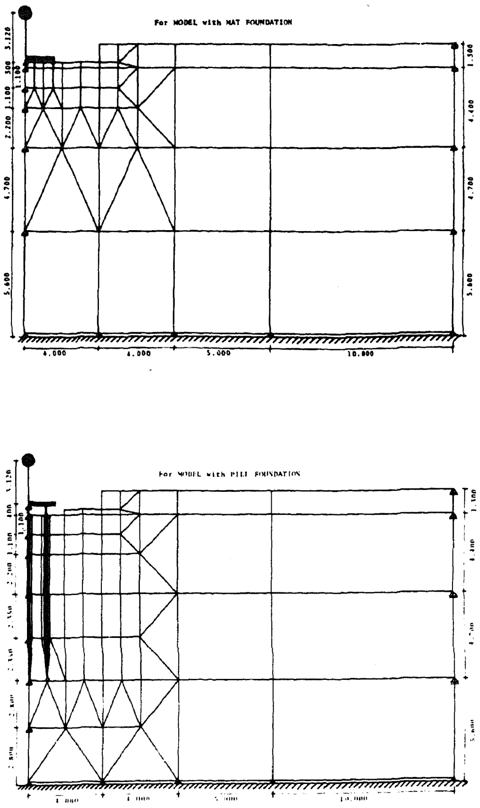

Fig.8 F.E.M. Models

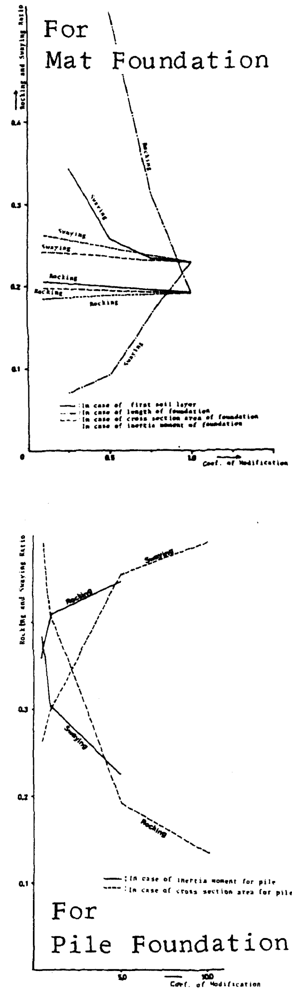

Fig.9 Carac. of Modifications

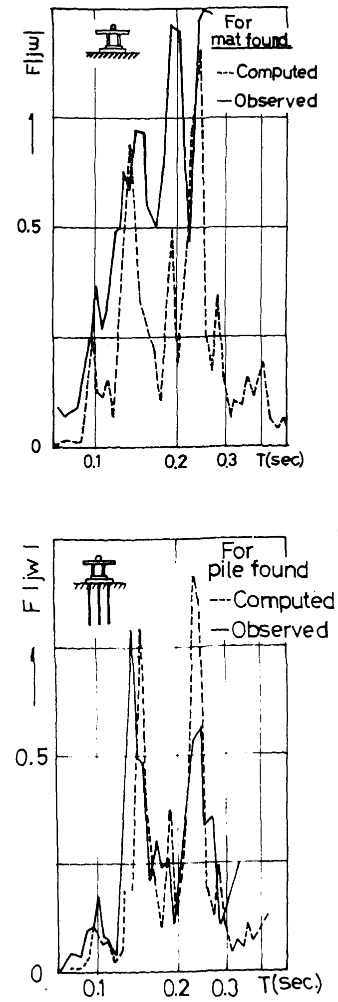

Fig.10 Fourie Specta

Table.1 Results of Experiments

Model Name	Kind of Experiments	Natural Period (sec)	Static & Dynamic K-vatue (t/cm)			Mode Shape (%)			Damping Coef.(%)
			K	K_V	K_H	(1)	(2)	(3)	
A	V_1A	0.126	415	137	236	32	35	33	5.4
	S_1A	-	415	184	232	20	45	35	-
	D_2A	0.16	88	94	154	27	49	24	15.0
	V_2A	0.13	120	133	180	38	38	25	11.0
	S_2A	-	138	163	235	41	34	25	-
B	V_1B	0.17	317	170	86	13	30	57	3.0
	S_1B	-	312	98	60	11	34	55	-
	D_2B	0.23	111	74	52	12	31	57	7.6
	V_2B	0.20	110	180	72	18	23	59	4.0
	S_2B	-	116	83	45	20	28	52	-

A : For model with mat foundation B : For model with pile foundation
V : Forced Vib.(for small) D : Forced Vib.(for middle) S : Static Load
K : Rigidity for superstructure K_V : Rigidity due to Rocking K_H : Rigidity due to Swaying
(1) - (Disp. due to Relation disp.)/(total disp.) (2) = (Disp. due to Rocking)/(total disp.)
(3) = (Disp. due to Swaying)/(total disp.)