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STUDY OF SOIL-STRUCTURE INTERACTION CONSIDERING WITH NEIGHBORING BUILDING AND TOPOGRAPHICAL IRREGULARITY

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ABSTRACT

In this report, for a PWR type nuclear power plant facility, the effect of topographical irregularity and a neighboring building on foundation input motion, soil impedance and transfer function of the super structure were investigated based on 2-dimensional plane strain FEM. It was found that in spite of the difference between the topographical irregularity and non-irregularity model's foundation input motion, the overall effects from both topographical irregularity and neighboring building on PWR type nuclear power plant facilities were insignificant.

1. INTRODUCTION

Many nuclear power plants have been constructed in places with topographical irregularity such as a back mountain. It has also been reported that such a topographical irregularity makes structures behave unexpectedly during the earthquakes from the previous seismic disasters (1990 Luzon Earthquake in Philippine).

Most nuclear power plant facilities, such as a reactor building, auxiliary building, etc., were built on independent rigid foundations. In spite of this condition, in most cases, the effect of these neighboring buildings were neglected in foundation input motion calculations, soil-impedance, etc.

Recently, much attention has been placed on the above two effects. Some research works have been published, but most of them have focused on only soil and wave propagation behavior.

From the above point of view, the object of this study is to evaluate these effects on not only soil and wave propagation behavior but also on super structure behavior.

In this report , for a simplified modeled PWR type nuclear power plant facility, foundation input motion, soil impedance and transfer function of the super structure were calculated.

From a representative earthquake, response analysis was also carried out to evaluate the maximum response acceleration of super structure.

2. ANALYTICAL MODEL AND INPUT SEISMIC WAVE

1) Soil Model

A 2-dimensional dynamic elastic plane-strain FEM was used for the soil and wave propagation analyses. Fig.1 shows the analytical models of the soil, which was modeled as a homogeneous viscoelastic half space with Vs=1500m/sec. Energy transmitting boundaries were used. Soil properties are shown in Table-1.

Model-A and Model-B were to evaluate the effects of topographical irregularity and Model-C and Model-D were to evaluate the effects of a neighboring building.

(1) MODEL-A
Model-A was a basic non topographical irregularity model. The rigid foundation of the reactor building was modeled 88m long with a step.

(2) MODEL-B
Model-B was a topographical irregularity model. The figure of the reactor building foundation was modeled the same as Model-A. The back mountain was modeled 200m wide and 100m high.

(3) MODEL-C
Model-C was a basic non neighboring building model. The rigid foundation of the reactor building was modeled 66m long, and there was no neighboring building.

(4) MODEL-D
Model-D was a neighboring building model. The foundation of the reactor building was modeled the same as Model-C and the rigid foundation of the neighboring building was modeled 57m long.

2) Super Structure Model
A simplified PWR type nuclear power plant lamped-mass model was used for the super-structure. Fig.3 shows the analytical super-structure model and the properties of the super structure are shown in Table-2.

3) Input Seismic wave
The maximum acceleration of the input seismic wave was 267gal. Input seismic wave time history is shown in Fig.2.

3. RESULTS OF ANALYSIS

1) Effects of Topographical Irregularity

(1) Foundation input motion
Fig.4 and 5 show a foundation input motion comparison between Model-A and Model-B, for both incident angles 0° and 30°, that were used to evaluate the effects of topographical irregularity. It was found that Model-B, which had a topographical irregularity, produced many peaks and valleys for both incident angle 0° and 30°
It was also found that the Model-B result, on the average, was a little smaller than Model-A. The results of incident angles 0° and 30° had similar tendency even though the foundation input motion shape shows a difference.

(2) Soil Impedance
Fig.6 and 7 show a soil impedance comparison between Model-A and Model-B for the topographical irregularity evaluation. The results of Model-A and Model-B were almost the same. The rocking spring (K_{RR}) of Model-B, which was a topographical irregularity model, showed some peaks and valleys when compared with Model-A. The sway springs (K_{HH}) of Model-A and Model-B were almost the same.

(3) Transfer function of super structure
Fig.9 shows a transfer function of the super structure comparison between Model-A and Model-B for the topographical irregularity evaluation. Even though the peak values of Model-A and Model-B transfer functions showed a little difference, the results of Model-A and Model-B were almost the same.

(4) Earthquake response analysis
Maximum response accelerations of the super structure are shown in Table-3. The results showed that maximum response accelerations of Model-B, which had topographical irregularity, were a little higher than Model-A. But the results of Model-A and Model-B were almost the same.

2) Effects of a Neighboring building

(1) Foundation input motion

Fig.6 shows a foundation input motion comparison between Model-C and Model-D for the effects of a neighboring building evaluation. The results showed that the transfer function of the super structure of Model-D, which was a neighboring building model, was a little higher than those of Model-C. But the results of Model-C and Model-D were almost the same.

(2) Soil Impedance

Fig.8 shows the foundation input motion comparison between Model-C and Model-D for the effects of a neighboring building evaluation. Even though the real part of the sway spring (K_{HH}) of Model-D, which was a neighboring building model, was a little higher than that of Model-C, the results of Model-C and Model-D were almost the same.

(3) Transfer function of super structure

Fig.10 shows a transfer function of super structure comparison between Model-C and Model-D for a neighboring building evaluation. The results of Model-C and Model-D were almost the same.

4. CONCLUSIONS

Effects of topographical irregularity and a neighboring building on foundation input motion, soil impedance and transfer function of a super structure were studied. A two-dimensional plane-strain FEM model for the soil and a simplified lamped-mass model for the super structure were used for a PWR type nuclear power plant. From this study , the following conclusions can be drawn ;

1) Topographical irregularity

(1) The effect of topographical irregularity on foundation input motion appears in many peaks and valleys. It may be necessary to check both foundation input motion and super structure frequency characteristics depend on analytical conditions.

(2) On the average, the foundation input motion of a topographical irregularity model is a little smaller than a non topographical irregularity model.

(3) In spite of the slight difference between the rocking spring non-irregularity and rocking spring irregularity, the effect of topographical irregularity on both sway and rocking spring is insignificant.

(4) The effect of topographical irregularity on an earthquake response analysis is insignificant in this study.

2) Neighboring building effect

(1) The effect of a neighboring building on foundation input motion, soil impedance and transfer function of a super structure is insignificant.

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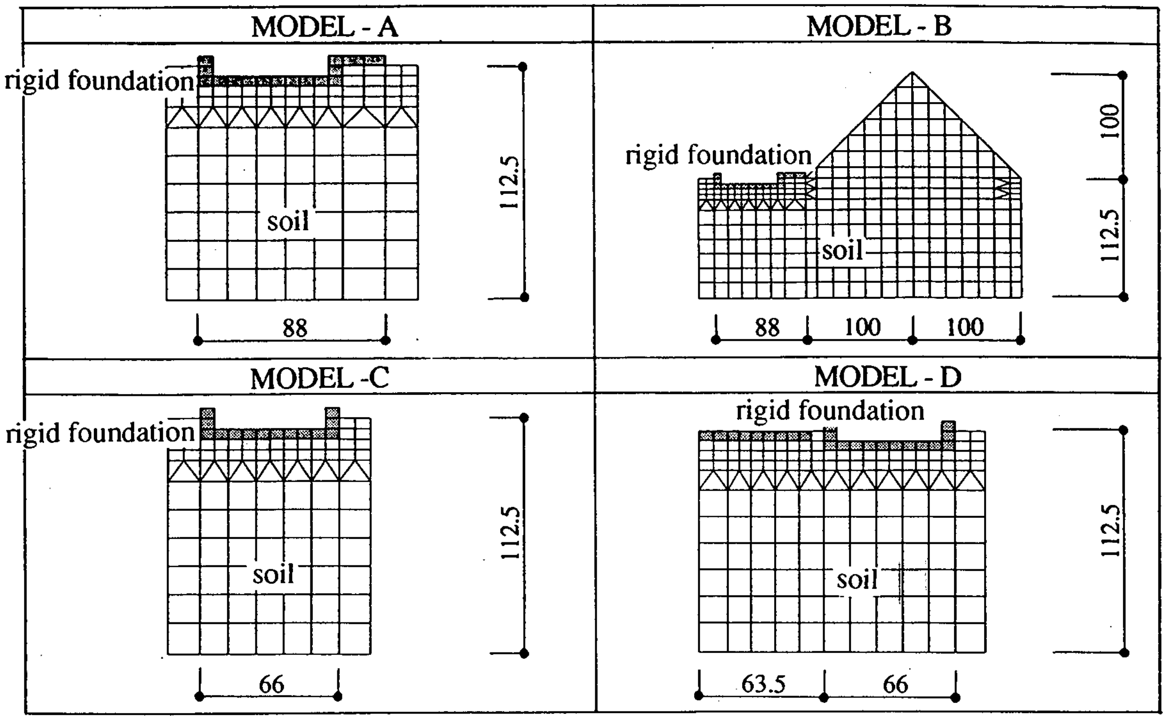

Fig.1 Analytical Models (soil) (unit = m)

Table - 1 Soil Properties

Unit weight (ton / m^3)	Shear wave velocity (m / sec)	Poisson's ratio
2.3	1500.0	0.38

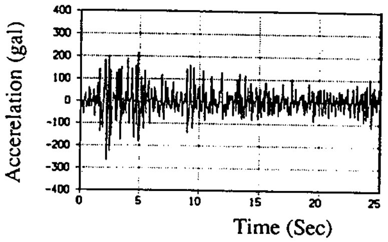

Fig.2 Seismic wave time history

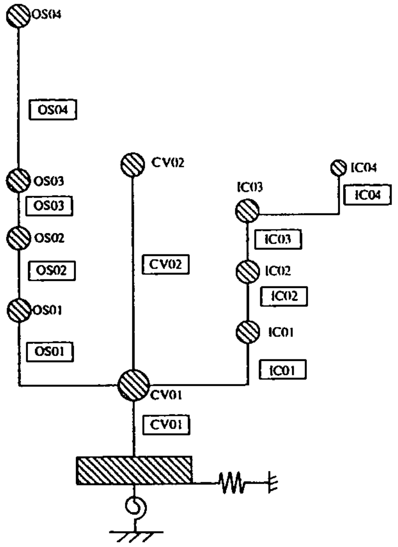

Fig.3 Analytical Model (Super - Structure)

Table - 2 Properties of Super - Structure

	Node No.	Elevation (m)	Weight (ton)	Elem. No.	Shear Area (10^4cm^2)	Moment of inertia (10^8cm^4)
IC	IC01	14.6	154.	IC01	2.02	143.
	IC02	22.8	94.3	IC02	1.92	155.
	IC03	29.3	38.2	IC03	0.58	5.74
	IC04	36.0	8.80	IC04	0.13	1.82
CV	CV01	6.88	378.	CV01	21.9	4646.5
	CV02	36.4	56.5	CV02	0.05	27.3
OS	OS01	16.5	468.	OS01	1.05	626.
	OS02	24.4	201.	OS02	1.05	626.
	OS03	32.8	122.	OS03	1.05	626.
	OS04	52.7	126.	OS04	0.93	520.
BS	B002	-2.50	1061.			

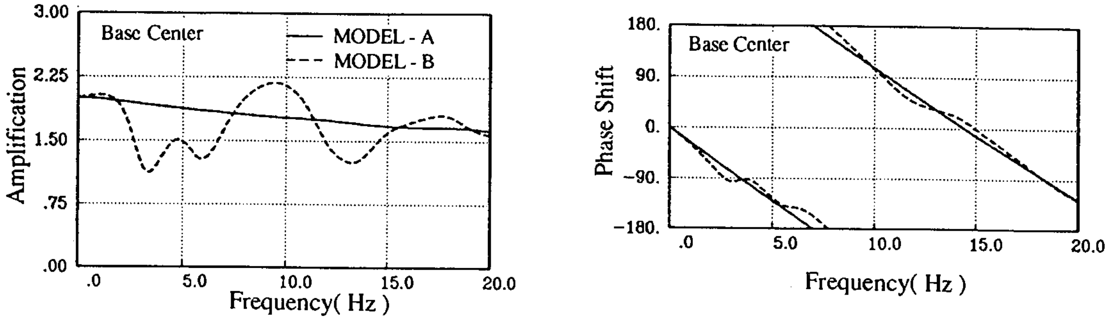

Fig.4 Effect of Topographical Irregularity on Foundation Input Motion ($\theta = 0°$)

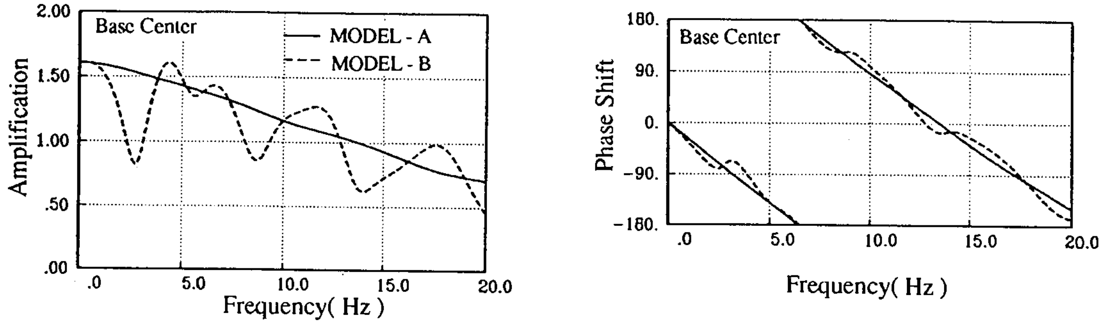

Fig.5 Effect of Topographical Irregularity on Foundation Input Motion ($\theta = 30°$)

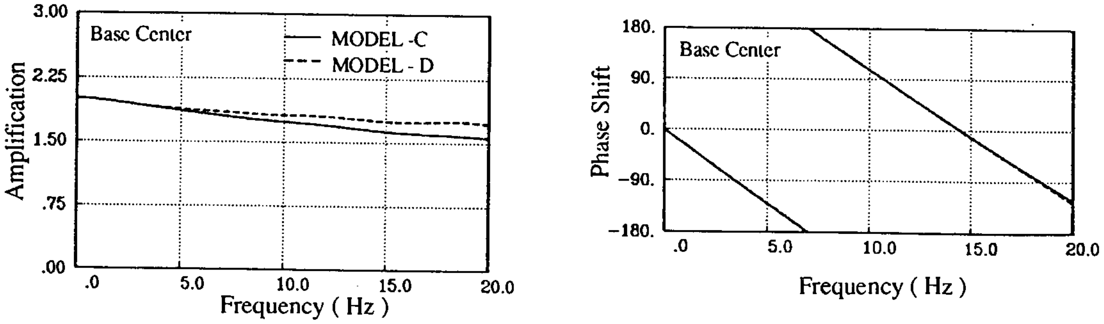

Fig.6 Effect of Neighboring Building on Foundation Input Motion ($\theta = 0°$)

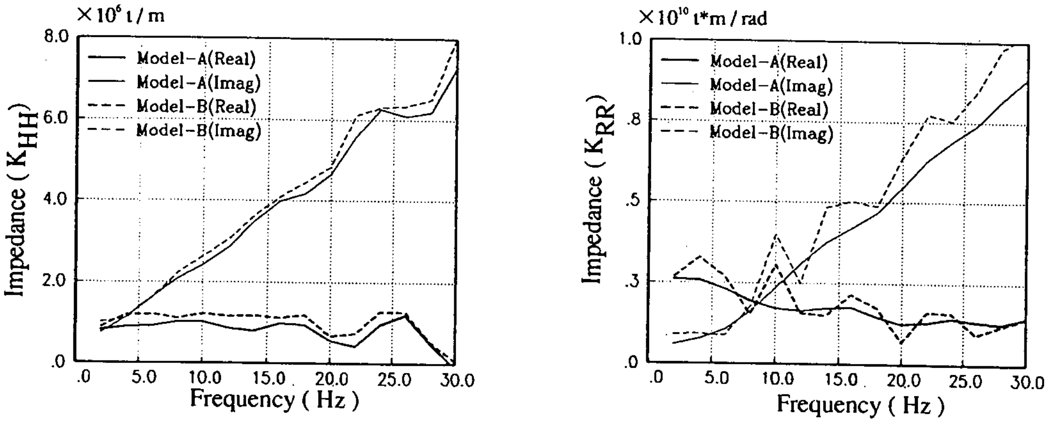

Fig.7 Effect of Topographical Irregularity on Soil Impedance

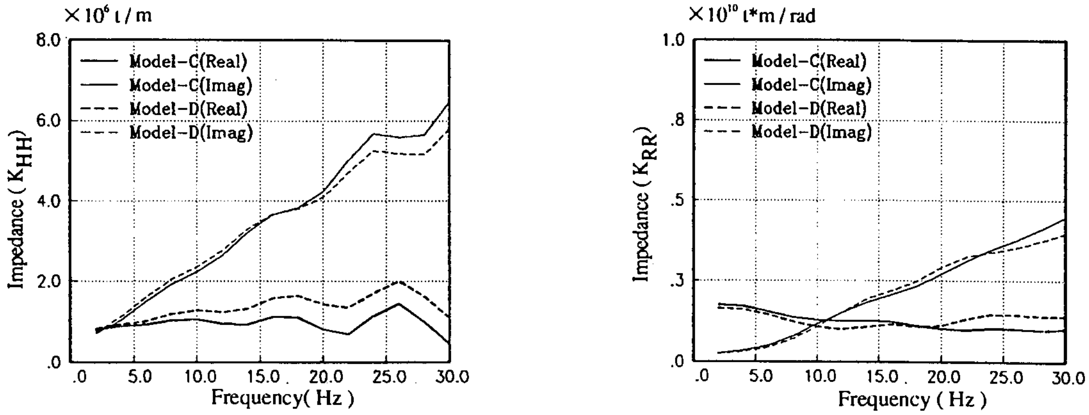

Fig.8 Effect of Neighboring Building on Soil Impedance

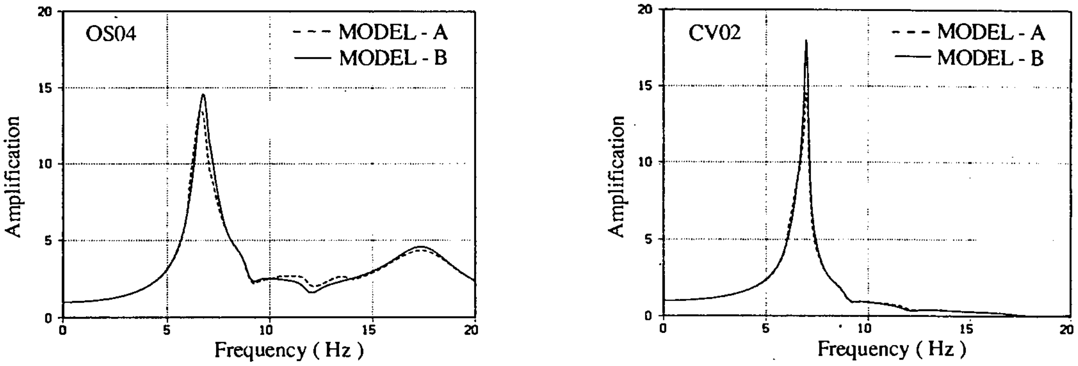

Fig 9 Effects of Topographical Irregularity on Transfer Function of Super Structure

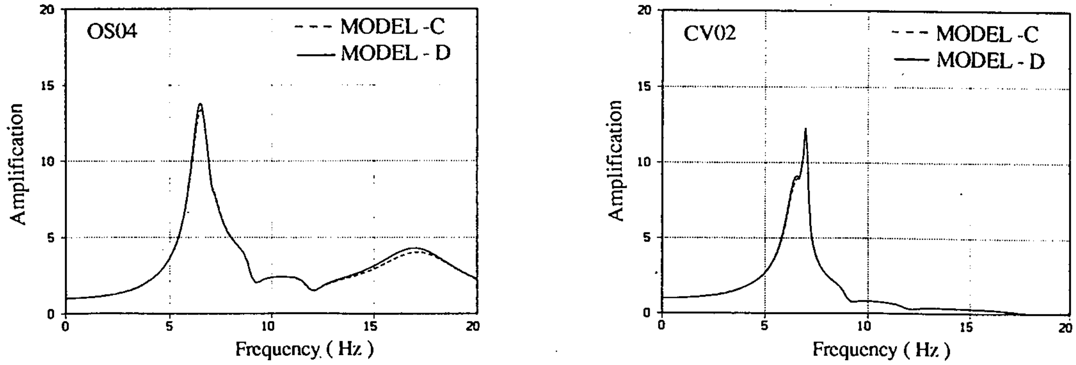

Fig 10 Effects of Neighboring Building on Transfer Function of Super Structure

Table - 3 Maximum Response Acceleration of Super Structure (unit : gal)

Node No.	OS04		CV02		IC03	
Incident angle	0.0°	30.0°	0.0°	30.0°	0.0°	30.0°
MODEL-A	1227.	1114.	769.	722.	832.	658.
MODEL-B	1128.	1146.	748.	585.	772.	606.