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Distribution of ground rigidity in Hualien project of large scale seismic test

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ABSTRACT: 1/ 4 plant model was constructed on the gravelly soil in Hualien, Taiwan, and the backfill material of crushed stone was placed around the model plant after excavation for the construction. The rigidities of the gravelly soil and the backfill material relate to the seismic behavior of SSI, so their rigidities were investigated in detail. The change of the elastic wave velocity of the gravelly soil were measured according to the performance of each stage of excavation, construction and backfill. And the distribution of the mechanical properties of the gravelly soil and the backfill are measured after the completion of the construction by penetration test and PS-logging etc..

1 INTRODUCTION

The mechanical soil properties of the foundation soil just around and beneath a structure, play an important role to evaluate the SSI effect. As a structure has sway and rocking behavior under earthquake, it leads to the change of lateral soil pressure around a structure, vertical soil pressure just beneath it and shear stress between it and the foundation ground. So it is neccesary to investigate the rigidities of the soils just around and beneath a structure (Kudo et al, 1994).

In general structure construction accompanies with several process of dewatering, ground excavation, cement concrete placing and backfilling, so foundation ground has 2 and/or 3 dimensional change of stress distribution and mechanical disturbance and their effects should be investigated in the field. The geotechnical investigation in HLLST project has been carried out in the field applying large penetration test and

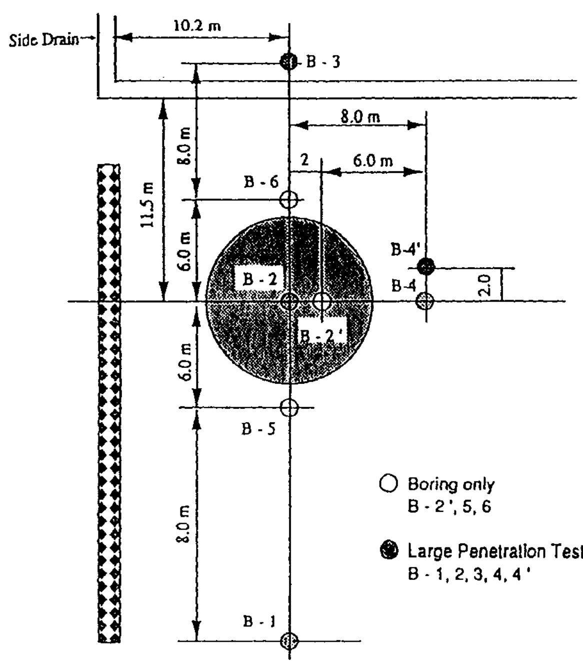


Fig.1 Location of Penetration Test and PS-logging Before Excavation

PS-logging, which were conducted just around and beneath the model plant before excavation (stage 1) and after backfill (stage 4) (Kokusho et al, 1993). Fig.1 and 2 show the location of these surveys before excavation and after backfill each other. This paper describes the distribution of the rigidities of both the gravelly soil of the foundation ground and the backfill around the model plant.

2 DISTRIBUTION OF RIGIDITY OF GRAVELLY SOIL

2.1 N_L before excavation

Fig.3 shows the results of large penetration test before excavation (stage 1) and N_L is the blow counts for 30 cm drive by Large Penetration Test. N_L ranges 20 to 40, and lineally increases with the depth. It seems that N_L does not depend on the location of penetration test. So it is concluded that the gravelly soil is homogeneous.

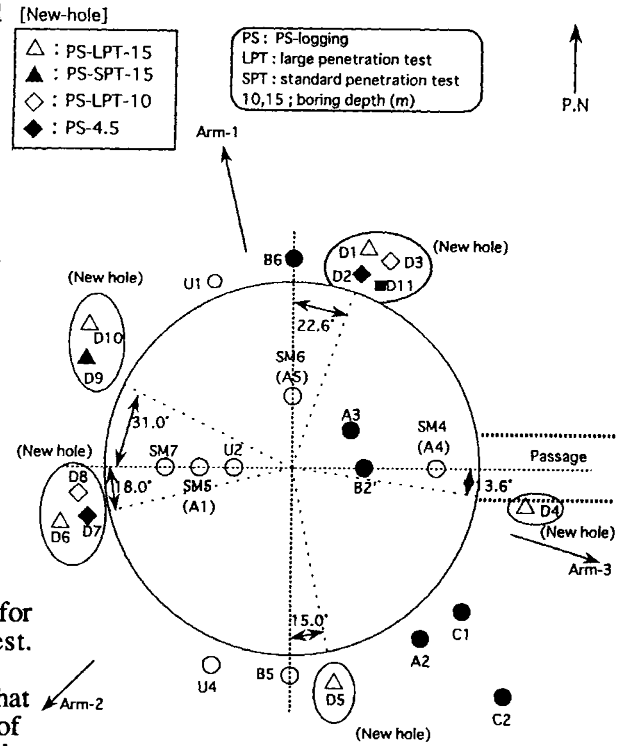
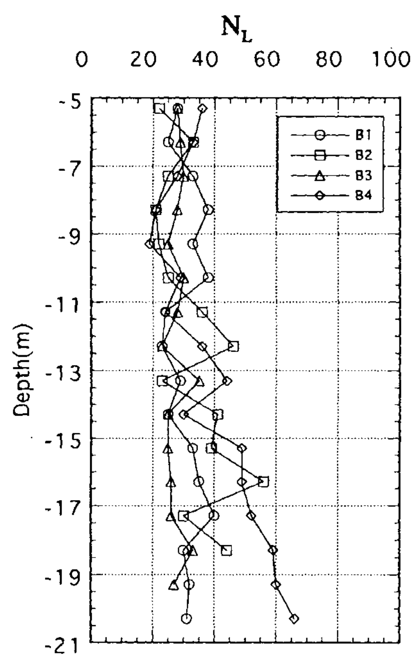


Fig.2 Location of penetration Test and PS-logging After Backfill



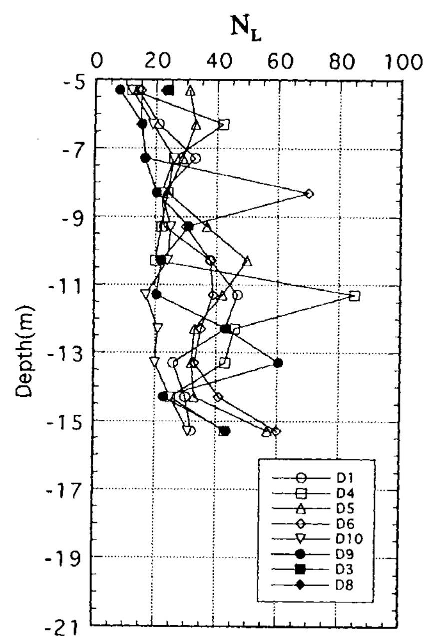


Fig.3 N_L of Gravelly Soil Before Excavation

Fig.4 N_L of Gravelly Soil After Backfill

2.2 N_L after backfill

Fig.4 is the results of the penetration test after backfill at the gravelly soil near the edge of the concrete mat foundation. Comparing with Fig.3 before excavation, it is found that N_L values at a depth of -5m to -8m after backfill are smaller than those before excavation, though it is thought that N_L in the gravelly soil near the edge of the concrete mat foundation should be increased. Because the stress just beneath the model plant should be increased due to the contact pressure of the model plant and the overburden stress of the ground around the model plant should not be changed because of small difference between unit weights of the upper sand layer before excavation and backfill material. There is a possibility that some disturbance due to dewatering, stress release and excavation performance etc. would cause to the reduction of N_L at a depth of -5m to -8m.

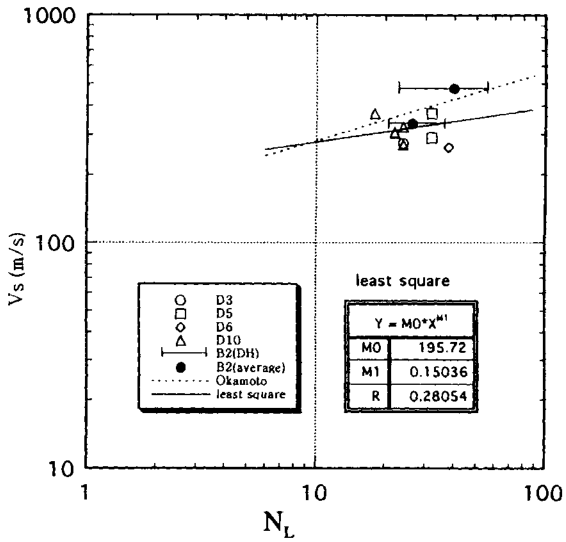


Fig.5 Relation Between N_L and V_S of Gravelly Soil

2.3 V_S- distribution after backfill

PS-logging by down-hole method and suspension method were applied at the location just around the model plant. where the penetration test were applied after backfill. However most of the received waves by them were not so clear due to the possible transferring to the concrete wall of the model plant that detailed V_S (shear wave velocity)-distribution of the gravelly soil after backfill was not measured directly.

Fig 5 indicates the relation between V_S and N_L by using only the clear received S wave data before excavation and after backfill. N_L values in Fig.5 are limited at about 20 to 30 and many formulas about the relation has been suggested (Yoshida et al, 1988), however the straight line obtained by least squre method can be applied to the relation in Fig.5.

V_S-distribution in gravelly soil is calculated by applying the relation, and it's result is shown in Fig.6. According to Fig.6, V_S of the gravelly soil distribute 280 to 350 m/sec, and it is found that these Vs values near the edge of the concrete mat foundation are smaller than 383 m/sec at the gravelly soil just beneath the center of the model plant and are a little bit smaller than

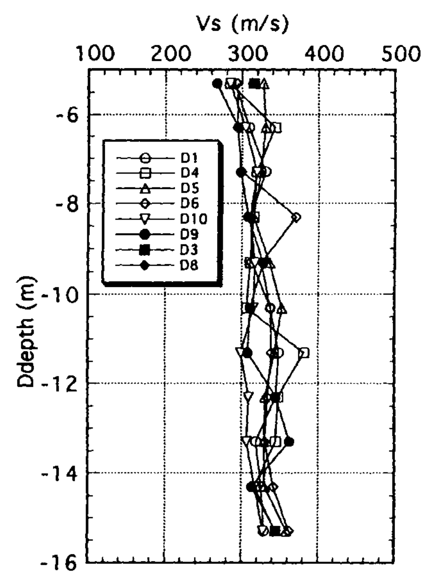


Fig.6 Estimated V_S of Gravelly Soil After Backfill

333 m/sec at the upper gravelly soil far from the model plant (Fig.11) (Okamoto et al, 1994,1995). However they increases with the depth and V_S at a depth of -8m becomes to be close to 333 m/sec.

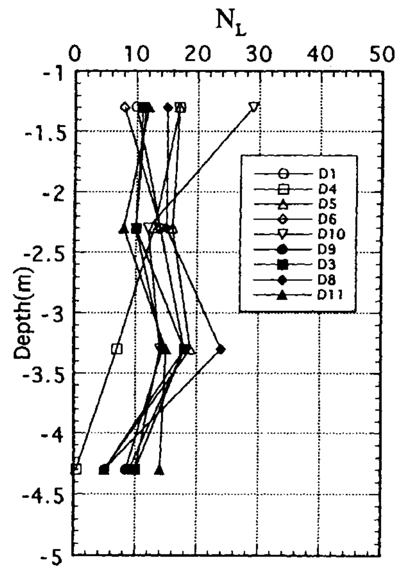


Fig.7 N_L of Backfill

3 DISTRIBUTION OF RIGIDITY OF BACKFILL

3.1 N_L after backfill

Fig.7 indicates the results of the penetration test after backfill just around the model plant. Most of N_L values range 8 to 18, sometimes backfill has 1 and 29 of N_L. 29 of N_L value indicates that the sampler would seems to encounter a bigger particle of the gravelly soil taking into a account of N_L-distribution, but 1 of N_L value shows the liquefaction of the gravelly soil at a depth of -4.5m is located under the water level. And generally speaking N_L value will be increased with depth in granular soil material, but N_L of backfill is not increased with the depth as shown in Fig.7. Especially N_L value at a depth of almost -4.5 m are smaller than the values at the upper gravelly soil.

3.2 RELATION BETWEEN N_L AND V_S OF BACKFILL

Fig.8 shows the relation between N_L and V_S by using only the clear received S wave data and the data in Fig.8 are measured at 1.0 to 1.5 m far from the model plant. It is found that the rigid straight line is obtained by leaset squre method and agrees with the modified Okamoto's formula, so it can be apllied for wide N_L value. Original Okamoto's formula ($V_S=125*N^{0.3}$ for dilluvial sandy gravel) uses N instead of N_L based on the assumption of $N=2.0*N_L$.

The relation between N and N_L is shown in Fig.9 about the backfill, N is the blow counts by Standard Penetration Test. In Fig.9 N value is sometimes too large, so LPT is valid on sandy gravel. And it is found that the relation of $N=2.0*N_L$ is satisfactory on Hualien backfill material.

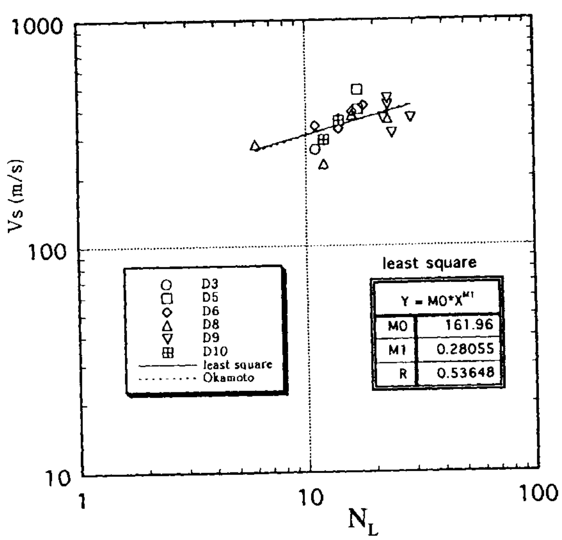


Fig.8 Relation Between N_L and V_S of backfill

3.3 V_s-DISTRIBUTION OF BACKFILL

V_s of backfill is calculated based on the modified formula, and the result is shown in Fig.10. It is found that V_s of backfill is estimated to distribute 300-360 m/sec and especially V_s at a depth of -4.5m is almost 300 m/sec. And V_s of backfill is smaller than V_s=383 m/sec of the ground model for analysis(Fig.11). So estimated value (300-360 m/sec) correspond to V_s just around the model plant instead of V_s far from it. It is possible that backfill just around the model plant would not be highly compacted.

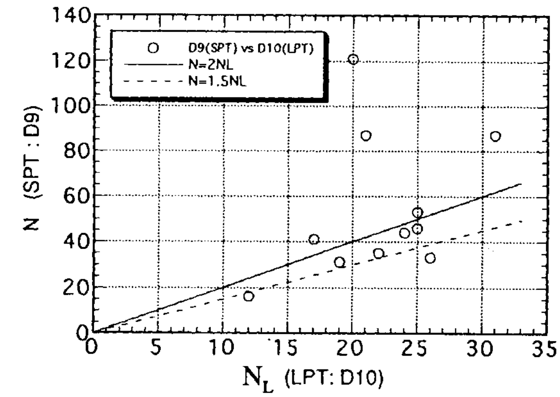


Fig.9 Relation between N and N_L on the backfill

CONCLUDING REMARK

Summary by the previous discussion is following:
(1) There is smaller V_s of the gravelly soil near the edge of the concrete mat foundation than V_s just beneath the center of the mat foundation.
(2) V_s of the backfill around the model plant is smaller than V_s far from the model plant. Especially V_s at a depth of -4.5 m is smallest.

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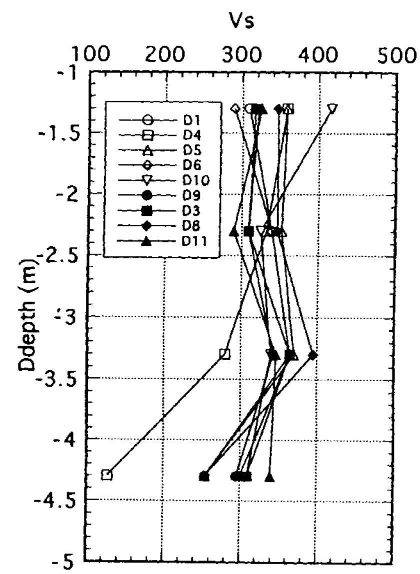

Fig.10 Estimated V_s of Backfill

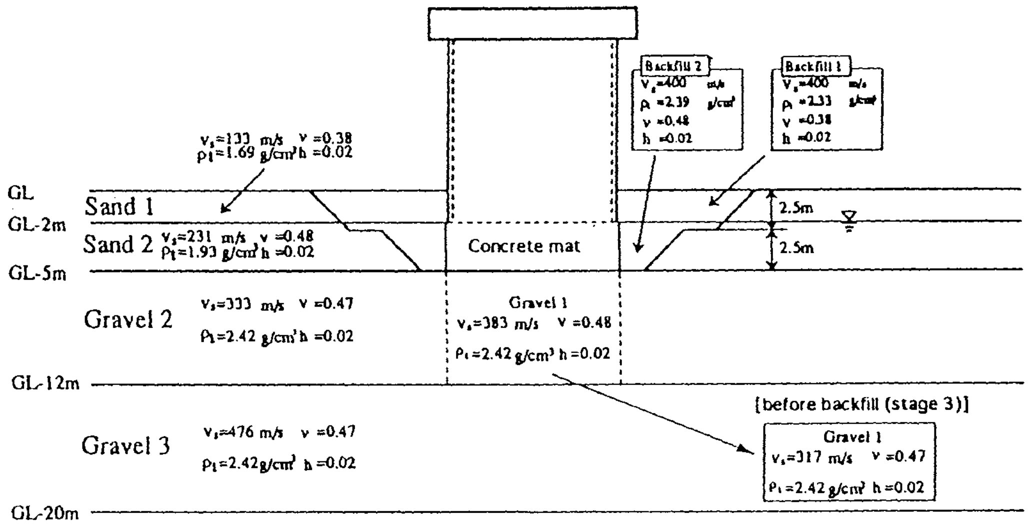

Fig.11 Ground Model for Analysis after Backfill

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