論 文 の 内 容 の 要 旨

論文題目　TRIAXIAL TESTS ON DENSIFICATION OF SAND BY STATIC LATERAL COMPRESSION　（静的側方圧縮による砂地盤の密実化に関する三軸せん断実験）

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In cohesionless materials a change in the angle of internal friction can be effected by changing the relative density, or by altering the particle size distribution by adding void-filling materials with or without cementation properties. We do not intend presenting examples of mechanical stabilization by improving the grading of sands, but rather to concentrate on densification improvement which would bring about strengthening the loose soil, mitigating the liquefaction risk as well. The need to improve unfavorable ground conditions to make it suitable for construction poses a new challenge to construction engineers. With the increasing use of the advanced technology in construction engineering greater emphasis is being placed on high reliability and its consequences. This study related with fly ash grouted pile, which is a new ground improvement technique without or least surrounding vibration and also considering for the recycling of thermal power plant waste materials. The injected materials exert pressure to surrounding soil and it displaces to some controlled extent. The growth of grout bulb in this technique is significant and the interface between the grout material and surrounding soil is clearly distinct without mixing or permeation into it.

The two major advantages in this technique are on

i. Environmental aspect: recycling of waste materials can save the loss of natural resources and reduce the amount of disposal to community society;
ii. Economical aspect: cost effective in replacement of using cement-base grout.

Accordingly, the present study is mainly concerned with the cavity expansion theory and how far volume contraction would take place under the monotonic

loading condition considering the stage of various stress paths based on the cavity expansion theory. Although different researchers have reported densification improvement for sand under very high pressure, it is necessary for the better way to understand the volume contraction behavior of sand under cyclic loading.

Consequently the following main objectives were established for the present research;

- To study the densification behavior of loose sands by means of the laboratory triaxial tests in order to find the efficient ways of grouting in practical uses.
- To investigate the effect of stress relaxation on long-term skin friction of grouted pile.

The above mentioned aims were attained by means of a series of experimental triaxial tests. Majority of test program was conducted on Toyoura sand together with other sand and fly ash. Careful analysis of all the test results was then carried out. The experimental part was performed with two different triaxial cells which were designated for low and high pressure. All the samples were tested under fully saturated condition by double vacuum method. The effect of using lubricated end method resulted in the smaller values of friction angle. Effects of curing pressure level and aging on the unconfined compressive strength of cement mixed fly ash sample were observed.

Triaxial test results on Toyoura sand showed positive volume strain, which means volume contraction, in various stress paths. Monotonic triaxial test however showed that static densification may not achieve enough volume contraction in various stress paths to mitigate liquefaction potential. It means that the normal way of injection with constant pressure controlled by single injection hole does not give efficient lateral compression to the nearby weaker zone to densify. However, cyclic triaxial test results in contrast show significant densification improving sand due to cyclic shear and principal stress axes rotation. In order to achieve the effective way of grouting for significant volume contraction for surrounding loose sand, this study proposes the efficient injection needed to produce the cyclic stress condition. It can be created in the real field by controlling injection pressure at multiple injection points alternatively.

The stress relaxation was studied after keeping the specimen under constant cell pressure and controlling no changing in axial strain for 2 days and then the estimation for the long term performance by the extrapolation on the logarithmic time scale for the design period was calculated. Thus long term stress relaxation was estimated in about 20 % reduction after 50 years. The residual stress state will

be an important role in order to calculate the lateral confinement of the grouted pile for its design life.

The stress paths were derived from both the cylindrical cavity expansion theory and spherical cavity expansion theory; the latter case obtained the initial gradient of the stress path 12% steeper than that of the former case near the cavity and similar at outer boundary. However, most tests were carried out by cylindrical cavity expansion theory.

The effect of dynamic pumping pressure at single injection hole in the field was studied. The injection pressure was reduced and increased alternately to reproduce two cyclic stress path conditions with minor stress reversal 2-way loadings such as (1) triaxial extension TE & minor stress reversal of triaxial compression TC or (2) TC & minor TE. The construction method assured simpler with controlling injection pressure at single point. This technology was similar to the previous way of injection in compaction grouting. The first case with majority in extension was effective way of reproducing the stress path in which the anisotropic behavior of sand and the importance of horizontal pushing was considered.

The radial stress decreased with distance "r" from injection point. Stress field reduction around the cavity expansion was calculated and then the effect of flyash injection to the nearby surrounding soil density was investigated by conducting a series of cyclic tests with full stress reversal at 4 different radial distances from the injection centre. This was taken as the upper bound value for the volume strain and as well as another series with minor stress reversal for the lower bound. Finally, the average volumetric strain for the nearby surrounding soil was calculated based on the integration of all the volume change results with related with the radial distances.

The results of the present study are needed to provide field verification on the effectiveness of soil densification due to the grouted piles installation for practical uses. The fly ash column will form additional reinforcement of subsoil, leading to consider the combined improvement with the surrounding sand.