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Behavior of sand replacement with geo-net on reclaimed marine clay

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ABSTRACT: The temporary road construction for dumped tracks or bulldozers on the dredged and reclaimed marine clay has adopted the sand replacement with geo-net. We have developed a new measuring apparatus which is two dimensional deformation system (2DDS), that can monitor the shape of the sand displacement. This paper shows the 2DDS mechanism, observating results and consideration.

1. INTRODUCTION

Man-made Island recently has constructed using dredged and reclaimed marine clay as a water front development. Up to the present, Kashii Park Port project and Island City project, in Fukuoka city, are in constructing stages. They will be approximately 536 hector area using dredged marine clay positioned a sea lane in Hakata Bay. Ground reinforcement by geo-synthetics has been applied to the several different sites in these area.

Among these sites, the temporary road construction for dumped tracks or bulldozers on the dredged and reclaimed marine clay has adopted the sand replacement with geo-net. Photograph 1, shows the construction site.

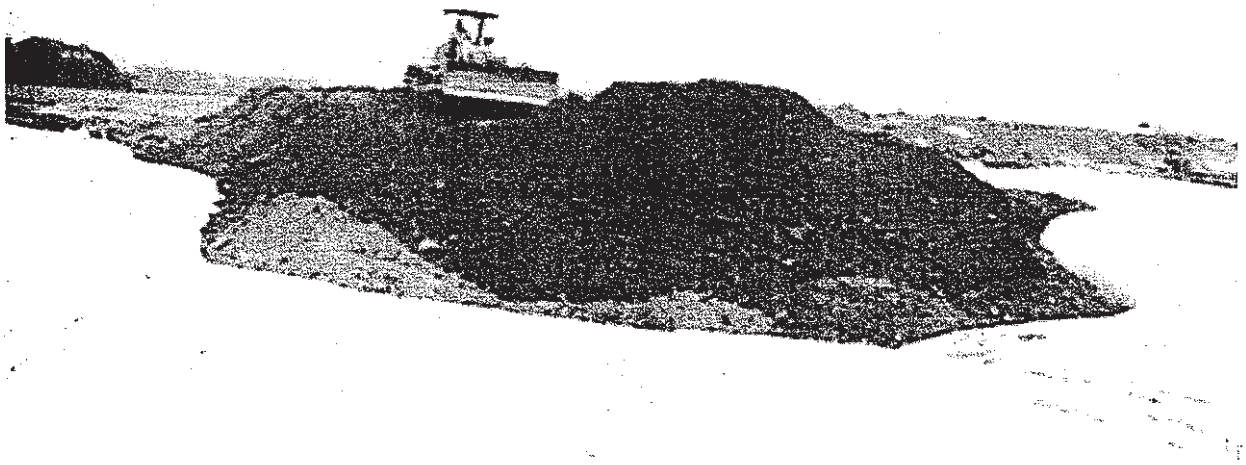
However, there is a few case study of the sand replacement with geo-net which subsides into the soft clay. And also theoretical consideration of these phenomenon, which is the plastic flow by the partial load, leaves something to be desired.

Therefore, this paper presents as follows;

(1) A new measuring apparatus that can monitor the shape of sand displacement on dredged and reclaimed marine clay.

(2) The result of the monitoring the geo-net behavior in the reclaimed clay, using the new measuring apparatus.

(3) The consideration of geo-net strain distribution and tension occurred during sand displacement.



Photograph 1: Construction site of sand replacement with geo-net

2. GEOTECHNICAL PROPERTIES

The undersea ground of these site consisted of holocene deposit marine clay in 7 meters thick and pleistocene deposit coarse sand in 10 meters thick, on the tertiary sand stone and shale.

Dredged clay has been reclaimed in 10 meters thick on these stratum.

Figure 1, shows the typical geologic column and geotechnical properties.

3. TEMPORARY ROAD CONSTRUCTION

Temporary road was built for making sure of trafficability.

To replace clay with sand, geo-net was used as a wrapping net of sand, and sand mass subsided into the soft ground.

Figure 2, shows the constructing site of temporary road.

Constructed process as follows;

(1) Lay geo-net on the soft ground with human power.

(2) Pushing out the sand on the geo-net.

(3) the sand's own weight forces the reclaimed clay to the both side of the sand mass with plastic flow.

(4) Replace clay with sand, making a sand passageway on the soft ground.

4. MEASURING APPARATUS

Figure 3, shows a schematic of 2DDS. Measuring device inside the double tube consists of piezometer and metal detector. A water proof inner bendable tube and outer elastic tube compose a double tube. Metal rings are at intervals of two meters around the outer tube. 2DDS can measure the strain acting the geo-net.

Photograph 2 and photograph 3 show 2DDS.

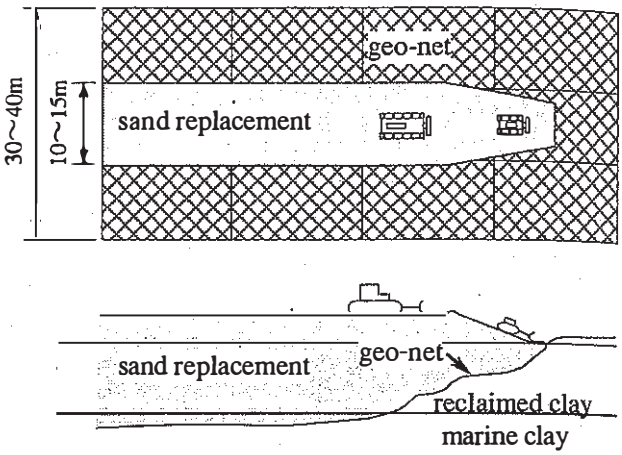


Figure 2: Temporary road construction

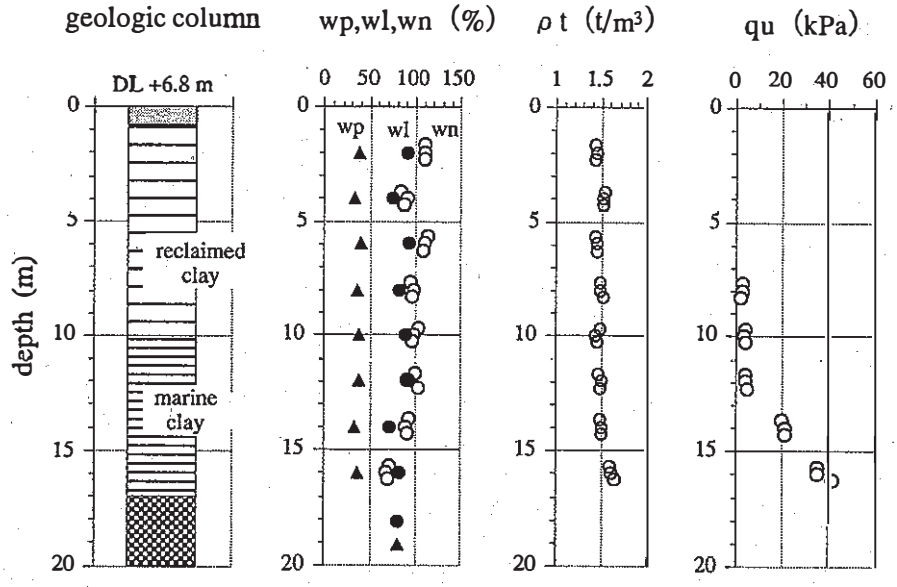
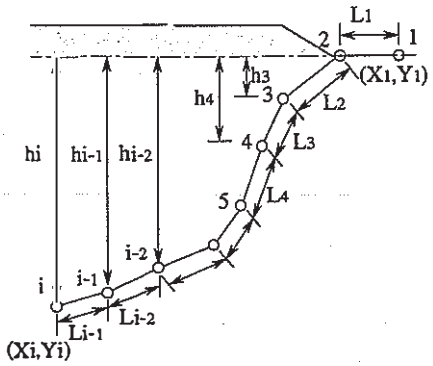


Figure 1: Geological column and soil property

Setting up the measuring apparatus follows next process.

Before pushing out the sand by bulldozer, 2DDS tube is fixed the geo-net on the reclaimed clay. Direction of fixing is perpendicular to the road center line. Inner tube is filled with water. After pushing out the sand, measuring tube subsides into the clay along the bottom end of the sand mass. Searching the metal target ring position by metal detector, and measuring the water pressure by piezometer. The coordinates of the observational points can be determine. Obtain data are oblique length (L) and depth (h). Therefore, it is possible to calculate the coordinates (Xi,Yi) as figure 4, and to determine the position of the geo-net and strain between two observational points side by side.

Moreover, a mark is following as next; compression is (+), tension is (-).



$$X_i = X_{i-1} + SQRT\{L_{i-1}^2 - (h_i - h_{i-1})^2\}$$

$$Y_i = h_i$$

$$\varepsilon_i = (L_{i0} - L_i)/L_{i0} \times 100$$

Figure 4: Determination of the geo-net position

5. REPLACED SAND SHAPE

Sand shape at every load step was shown in Figure 5. In the early load step, geo-net formed hammock shape. Sand mass subsides into the soft ground leaning toward the left side.

In proportion to the sand load increasing, the bottom of the geo-net subsides vertically with a little extending. However, the shape of the geo-net changes a hammock to a pot. Sand mass subsides into the soft ground keeping the pot shape. Finally the equilibrium border between sand and clay was at 1.5 meters beneath the border between marine clay and reclaimed clay.

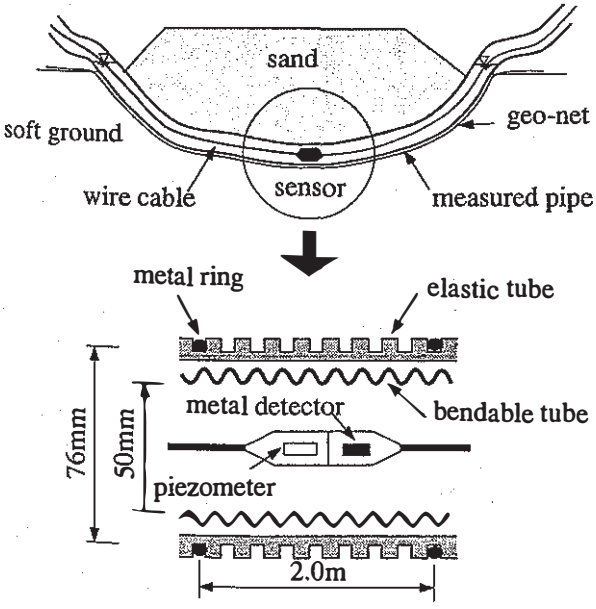
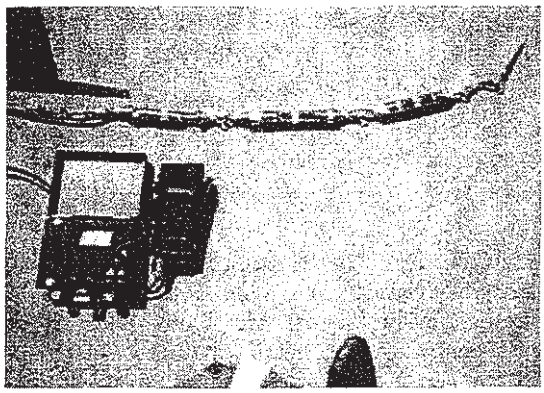
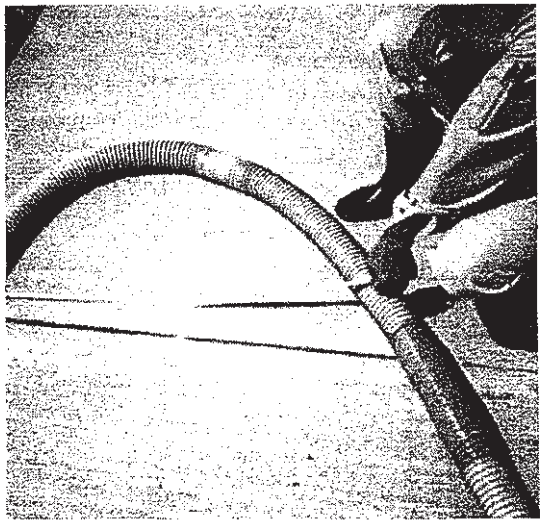


Figure 3: Schematic of the 2DDM (two dimensional displacement meter)



Photograph 2: Measuring device



Photograph 3: Double tube

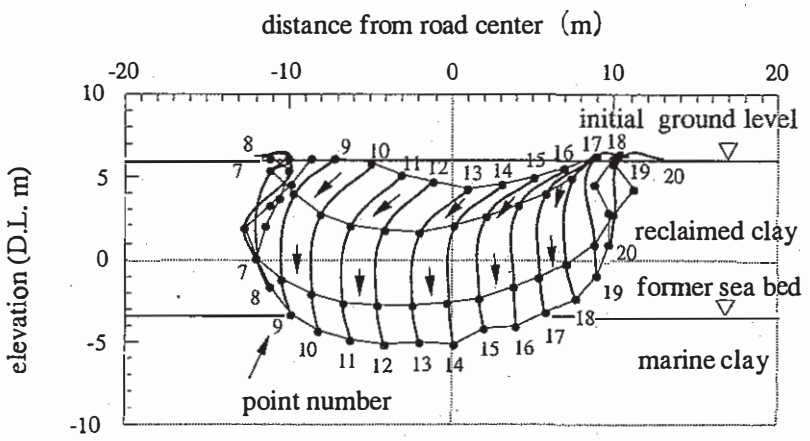


Figure 5: Locus of the observatinal points

6. DISTURBANCE UNDER THE SAND MASS

Figure 6, shows the unconfmed strength of the soft clay under the sand mass and its strain. The strain distribution shows that disturbance under the sand mass came up to 2.0 meters in thickness beneath the geo-net.

7. GEO-NET STRAIN DISTRIBUTION

Figure7, shows the geo-net distribution at each load step. In the early load step, Tensile strain occurred throughout the geo-net. Maximum values which is 7 or 8 percentages occures at the both ends and center of the geo-net. Tensile strain does not increase in proportion to the sand weight but tends to uniformity .

After the sand replacement sufficiently formed, compressive strain was appearing in the both sides of the geo-net . The value of tensile strain is decreasing throughout the bottom end of the sand mass.

When the sand mass is located in the reclaimed clay, tensile strain occurs on the geo-net. When the bottom of the sand mass reaches the marine clay, tensile strain is disappearing in the both sides.

On the other hand, we measured the tension using the tension meter on the same points of 2DDS. They are point number 7,13 and 19. The results shows in figure 8 and figure 9. Through these figure, the behavior of the tension during sand replacement is as follows.

According to the measuring data of the center and the right side point, maximum tension occurs during the first stage. After the first stage, the tension stabilizes at the same level. In the left side point at 7, there is no maximum tension. The values of tension are constantly 5 to 15 N/m. These are the same behavior against the 2DDS measuring.

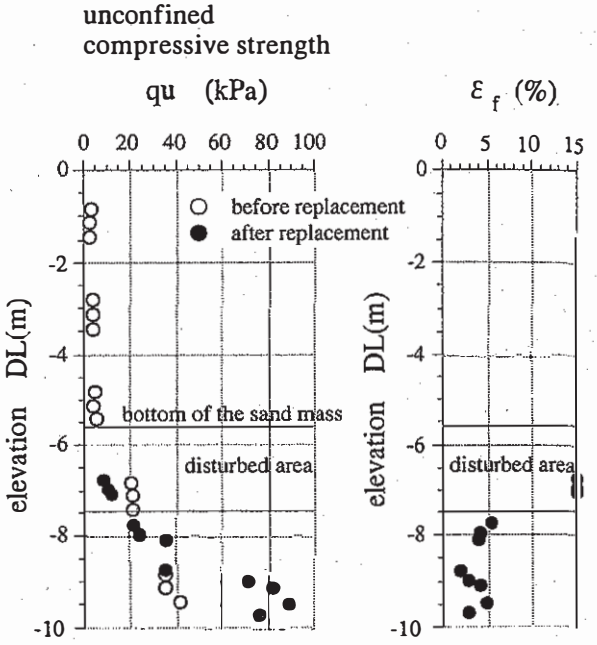


Figure 6: Disturbed area under the sand mass

8. CONCLUSIONS

Using the new measuring apparatus, geo-net behavior can be defined.

Cross section of the sand replacement is a hammock shape during initial state which loads the light weight, and the maximum tension occurs.

In proportion to the loading, Plastic flow occurs in the reclaimed clay layer and cross section is similar to the pot shape, but the tension of the geo-net is stabilizing.

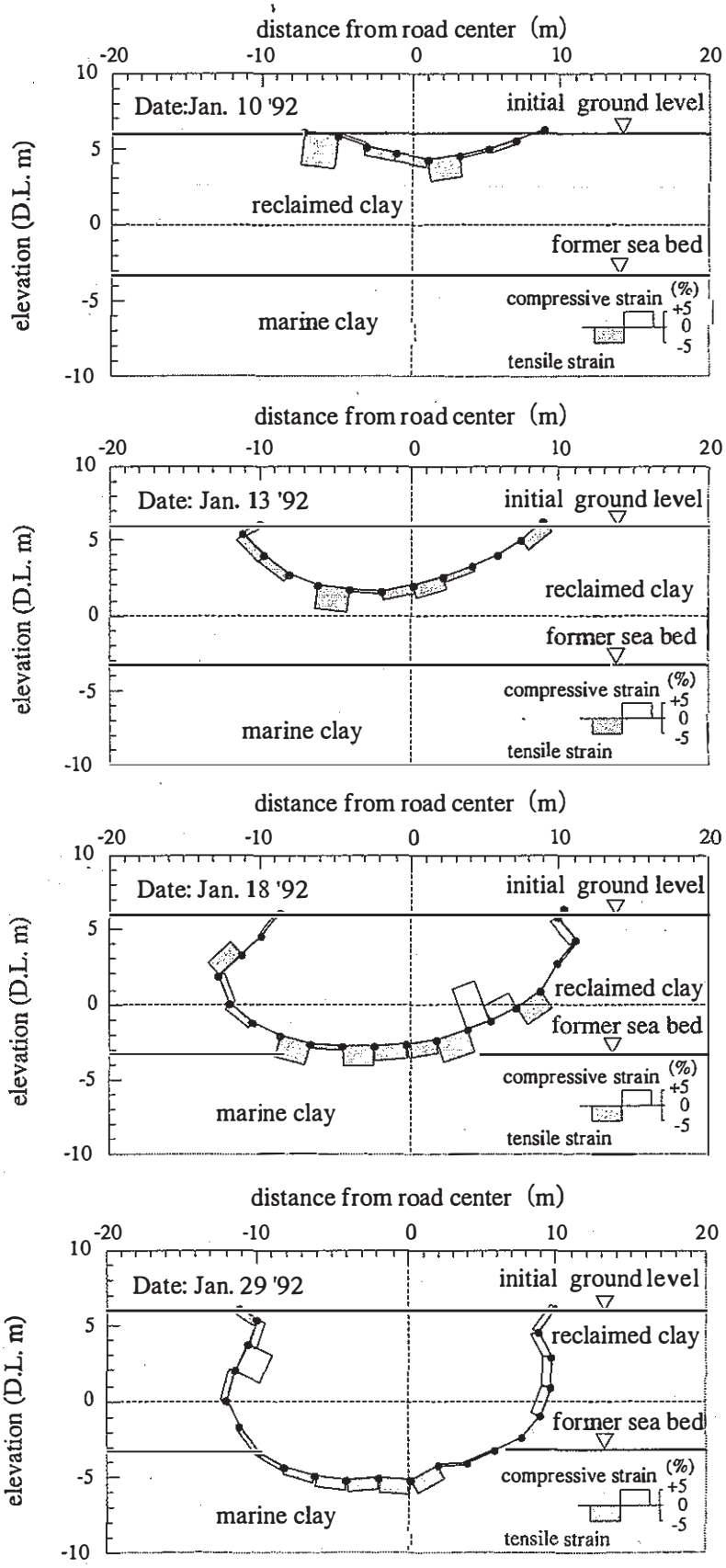


Figure 7: Geo-net strain distribution caused by sand replacement

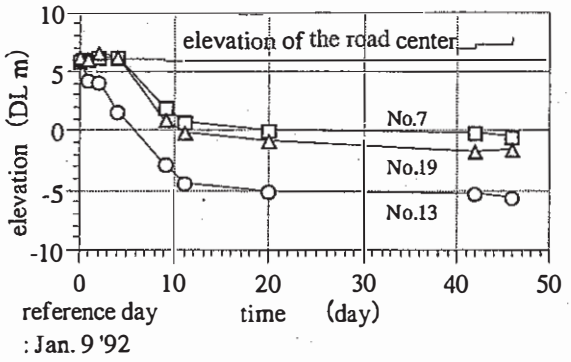


Figure 8: Geo-net settlement data for 50 days

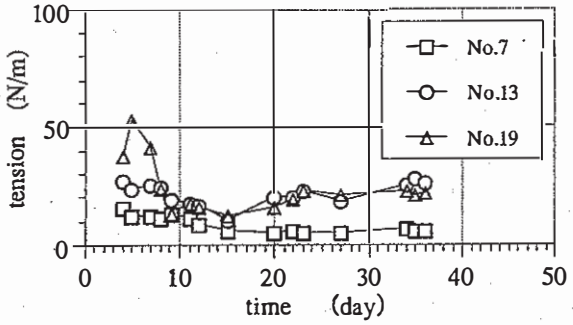


Figure 9: Geo-net tension data for 50 days

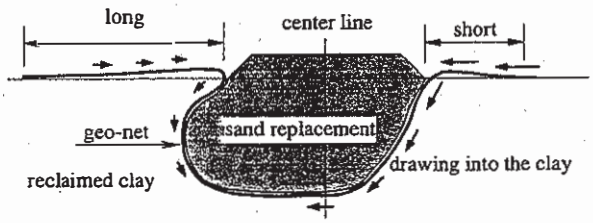


Figure 10: Geo-net drowing into the clay

A lean of the geo-net is determined by the position of the initial loading.

When the bottom of the sand mass reaches the marine clay, sand mass becomes impartial shape. Therefore tension acting to the geo-net in the marine clay is uniformly dispersing, and tends to decrease against the initial tension, and also the tensile strain is disappearing in the both sides when the bottom of the sand mass reaches in the marine clay.

We measured the behavior of the geo-net using 2DDS and tension meter.

From the measuring data and the construction site observation, we can also find that the outline of the sand mass can be determine by the remaining length of the geo-net on the surface as shown in figure 10.

And also the examination at the initial hammock state is effective to design the geo-net.

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