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Deformation measurements of test embankments reinforced by geocell

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ABSTRACT: We constructed two full-size test embankments reinforced by a geocell. One of them was made by only loam soil which is recognized as problematic soils, while other was made by loam soil and macadam. We performed failure tests of the embankments after measuring the horizontal displacements and the heights of them for about two years. We can understand from the measurements and failure tests that the embankments made only by loam soils is stable and safe as well as other one. We can confirm the possibility of using surplus soils for the filling materials.

1 INTRODUCTION

Recently, soil slopes reinforced by geocells (Sitharam et al. 2005; Krishnaswamy et al. 2000), which are one of the three-dimensional geosynthetics materials, have been constructed gradually. If we can use local surplus soil as fillings in the geocell, the geocell is very useful for reinforcement of soil. The geocell-reinforce method with surplus soils has many advantages for natural environments and construction costs. However, in the present circumstances, because mechanical behavior of geocell-reinforced soil structure is complex and not clarified, we use macadam, which is considered comparatively good quality. Moreover, a reasonable design method of the geocell-reinforced soil structures made with the surplus soil has not been established.

We constructed two full-size test embankments reinforced by the geocell in Hachinohe which is very cold region (omori et al. 2006). The shape of these embankments is the frustum of cone. We used the macadam and the loam clay for one of them, while we used only loam clay for other one. We measured the deformation of them for about 700 days. Measured items for embankments are the horizontal displacements and the height. In addition, we made failure tests of them in order to investigate the strength and the failure mechanism. we also examined the condition of inner soils such as the moisture content. Our main purpose in this study is investigation of the possibility of valid utilization of local surplus soils as inside materials of geocells.

2 OUTLINE OF TEST EMBANKMENTS

Figure 1 shows a photograph of one of the test embankments. We illustrates a outline of the test embankments in Fig. 2. We made the shape of the test embankments

Figure 1. Test embankment in 700 days since construction.

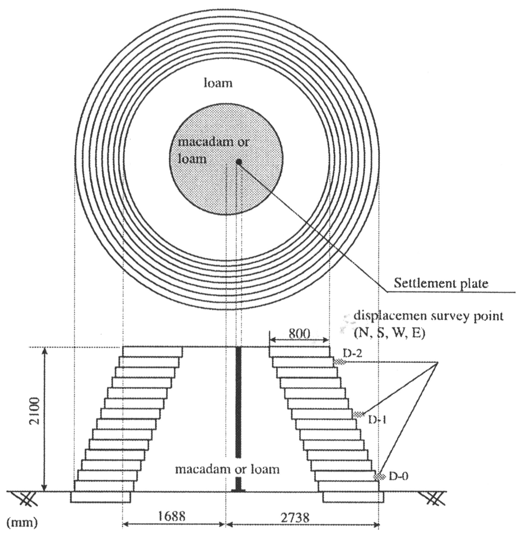

Figure 2. Outline of test embankments

the frustum of cone, in order to be isotropic state. (Radius of bottom 2738 mm, radius in top 1688 mm and height 2100 mm.) The geocell (omori et al. 2006) used in this study is made by high density polyethylene (HDPE) and is honeycomb-like continuous cells.

We constructed Embankment A by using only Hachinohe loam soil for the filling and backfill materials, while we constructed Embankment B by using macadam C-40 for the backfill. Our main purpose in this study is to examine the possibility of the employment of the surplus soil in the geocell reinforced soil wall construction method. Therefore, the loam soil that is one of the most difficult geo-materials was used for the filling materials.

3 LONG-TERM SURVEY OF TEST EMBANKMENTS

3.1 *Height of embankment*

Figure 3 shows the variation of the height of Embankment A and Embankment B for about 700 days. Variations of height both of Embankment A and Embankment B hardly change 700 days after construction and were under 4 mm. The variation of Embankment A is fewer than that of Embankment B. Moreover, we can understand from this figure that they are stable perfectly after about 300 days. We can say that even if we use the loam clay as the filling in the geocell, the height of the geocell-reinforced embankment is almost invariable.

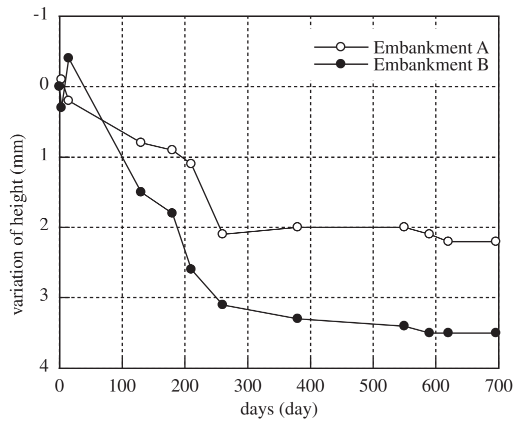

Figure 3. Variation of height of embankments

3.2 *Horizontal displacement*

Figure 4 shows the horizontal displacement results, which were measured by the electro-optical distance apparatus in measurement point D-0, D-1 and D-2 shown in Fig. 2. Figure 4 shows the relation between the lapsed days and the displacement, which was measured in four azimuths of north, south, east, and west.

The displacement both of Embankment B and Embankment A shows almost same tendency. The displacement of Embankment A is small rather than Embankment B. In about 200 days, the variation of the displacement is rapidly increase. We can consider that its reason is the first rainy season. After the first rainy season, they are very stable, although we can observe a little variation in the second rainy season that is about 550 days. In Embankment A, the horizontal displacement increases suddenly on about 200 days. On the other hand, in Embankment B, the displacement increases gradually for 200 days.

4 FAILURE TESTS OF EMBANKMENTS

4.1 *Outline of failure test*

Outline of horizontal loading for failure is shown in Fig. 5. We cut down the upper part from the half of the height of the embankments, though 1/5 part was left for failure tests. We pulled out to the horizontal direction the left part in the upper part of Embankment A by using a large-weight backhoe through the wire. The load cell of 20 tons in capacity was installed in the wire. If we assumed that unit weight of the loam soil is 2.0 g/cm^3, own weight of the left upper part of Embankment A is about 6.8 tons. When the horizontal load reached prescribed value, we measured a

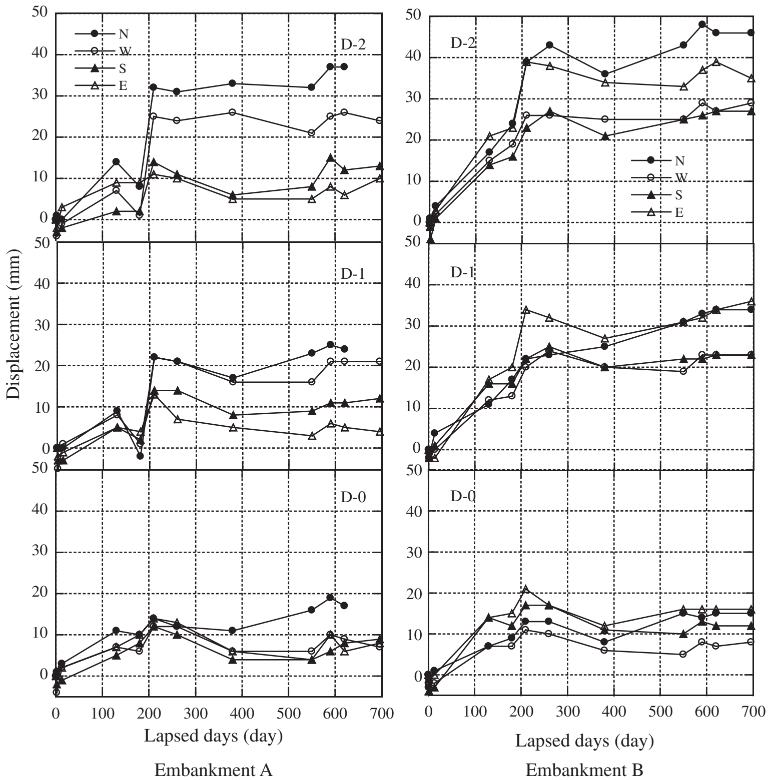

Figure 4. Results of displacement measurement

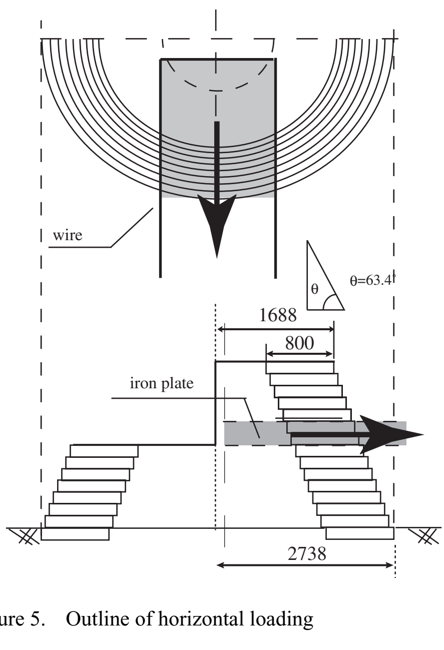

Figure 5. Outline of horizontal loading

horizontal displacement and observed the condition of Embankment A.

We also measured the moisture content in both Embankment A and Embankment B. The soil samples were gathered at the failure tests carefully. We put the samples in airtight containers, and carried them to our laboratory. We measured the moisture content by following JGS 0122.

4.2 *Results*

The situations of the failure test are shown in Fig. 6. Figure 6(a) shows the initial situation of the test for Embankment A. Figure 6(b) shows the state at the failure, and Figure 6(c) shows the situation after the failure. We can observe that Embankment A failed by a sliding at a boundary between lower and upper part.

We shows the relationship between the horizontal force and the horizontal displacement in Fig. 7. The horizontal displacement is very small until the horizontal force reaches 3 tons. The displacement begins to increase gradually when the force exceeds 3 tons, and the displacement increases rapidly when 5 tons are exceeded. Embankment A failed at the horizontal

(a) Preparation of failure test

(b) Situation at the failure

(c) Situation after the failure

Figure 6. Situation of failure test (Embankment A).

force 6.5 tons, which is a little smaller than the self weight.

We show the distribution of moisture contents in the Embankment A and B in Fig. 8. The moisture contents of Embankment B, which is made by using macadam for the backfill material, is somewhat smaller than that

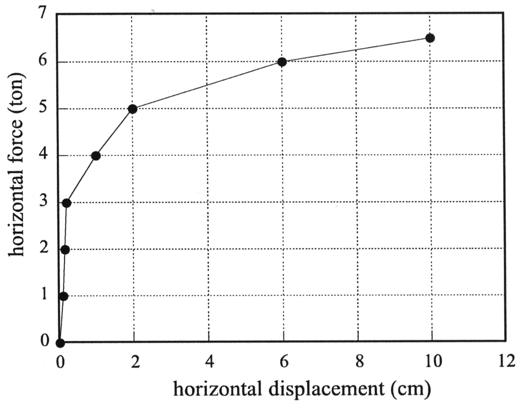

Figure 7. Relationship between the horizontal force and displacement.

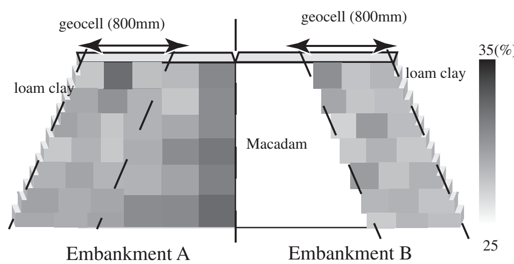

Figure 8. Distribution of moisture content in embankments

of Embankment A. In Embankment A, the moisture contents of the center part are larger, and maximum value is almost 34%. We confirmed that the drainage was better in using macadam for the backfill. However, we can say that the moisture content doesn't increase perilously even when we made the embankment by using only the loam clay, which is known as one of the difficult soil.

5 SUMMARY

In this paper, we constructed two full-size test embankments reinforced by the geocell. The test embankments were made by using loam clay and macadam for filling and backfill materials. We performed the failure tests of them after long term deformation survey. We can understand from these experimental results that the embankments made only by loam soils is stable and safe as well as other one. In addition, we can confirm the possibility of using surplus soils for the filling materials.

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