Geosynthetics, J. Kuwano & J. Koseki (eds)
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Field observation of reinforced soil retaining wall of "double wall structure"

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Keywords: reinforced soil wall, geogrid, field observations, deformation

ABSTRACT: Many types of reinforced soil retaining wall have been proposed and have been built worldwide. However, because earth pressure acts directly on facing material of wall, there is the possibility of swelling of facing material and lack of soil compaction near the facing material. In addition, it is confirmed from past cases that stress concentration occurs with consolidation of embankment near connection part between reinforcing material and facing material of wall, and breakage possibility of its connection part become high. We developed a new reinforced soil retaining wall system having a vertical layer which absorbs the deformation between facing material and reinforced fill. The layer prevents the earth pressure from exerting directly on the facing material. We call the system "double wall structure". Subjected to an actual structure of this system, we performed field observations during construction and after constructions in order to evaluate the performance of system. This paper reports the characteristics and functions of "double wall structure" obtained by the field measurement results.

1 INTRODUCTION

As for the reinforced soil retaining wall where earth pressure acts directly on facing material of wall, these problems, such as swelling of facing material of wall, and lack of soil compaction, are worried about. In addition, it is confirmed from past cases that stress concentration near facing material occurs with the consolidation of embankment near at connection between reinforced material and facing material of wall, and the breakage possibility of its connection part becomes high. Therefore we have developed a reinforced soil retaining wall method of construction that have double wall structure that earth pressure does not act directly on facing material of wall, as a new method of construction. We performed field measurements to verify the load acting on connection of facing material of wall of this construction method, the distribution of tension acting on reinforced material, and the distribution of subgrade reaction. This paper reports these results.

2 REINFORCED SOIL RETAINING WALL WHERE EARTH PRESSURE ACT DIRECTLY ON ITS FACING WALL

Photo-1 is case example where a facing wall of a reinforced embankment retaining wall collapsed in 1995. Height of its reinforced soil retaining wall is 12 m. Embankment of about 20 m high, and 1.80 gradient was put on it. Connection material made of metal, 150 KN/bar was used at the connection between facing wall block and reinforced material. In addition, the joint part between the facing wall block and the connection material made of metal was slide style capable of accommodating the consolidation of embankment. The backfill was the structure that directly contacted with facing wall block. The facing wall block entirely collapsed, remaining the collapsed slope of about 0.1 gradient, and the collapsed slope remained with the form that self-stood by the geogrid

Photo-1 Example of collapse of reinforced retaining wall.

reinforcing the embankment. As for the connection material made of metal, most of these were broken at the root with a facing wall part. In the connection material made of metal collected, some had already corroded at their ends. The main cause of this collapse is thought to be a local consolidation by a piping phenomenon with rain penetration water and a consolidation of entire embankment by slaking phenomenon. However, we thought that there is a problem in attributing only these to the real cause of collapse (a breakage of connection material made of metal), we, came at the development of double wall structure.

3 STRUCTURE

3.1 *Double wall Structure*

The structure drawing of double wall structure is shown in Figure 1. The detailed drawing of geogrid is shown in Figure 2. In addition, Photo-2, Photo-3, Photo-4 and Photo-5 are photos of construction situation of this reinforced soil retaining wall. This reinforced soil retaining wall has two facing walls comprising an outer wall and an inner wall. The facing wall block exists as the outer wall, and the inner wall comprising a non-woven fabric and L-form wire net exists in the inside. The embankment self-sustains stably by the inner wall and geogrid. In order to reduce the earth pressure acting from embankment to facing wall, facing wall block and embankment are separated perfectly, as shown in Photo-5. Between

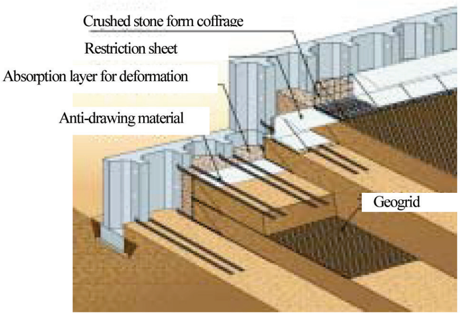

Figure 1. Structure drawing.

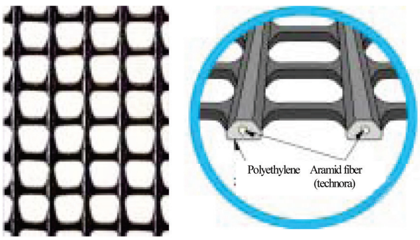

Figure 2. Detailed drawing of geogrid.

Photo-2 Situation of installation of anti-drawing material

Photo-3 Situation of geogrid installation

Photo-4 Situation of compaction adjacent to facing wall

Photo-5 Absorption layer for deformation (before input of crushed stone/View from top down)

the facing wall block and the embankment, an absorption layer for deformation comprising single sized crushed stone is set. facing wall block is not connected with geogrid laying in embankment.In addition, the facing wall block is unified with the embankment by flexible and noncorrosive polyester made fiber belt (below called, anti-drawing material).

3.2 *Characteristics*

(i) At the time of construction, some space exists for the absorption layer for deformation between facing wall block and embankment, and so, both are perfectly separated. Therefore, this construction method is enable to compact backfill near the wall surface sufficiently so that it is enable to promote the deformation of backfill under the construction

(ii) This construction method is capable of reducing the earth pressure acting on the facing wall block, with mitigating the external stress concurrent with the deformation of compression of embankment after construction by the absorption layer for deformation.

(iii) As a flexible material is used as anti-drawing material, this construction method is capable of accommodating the deformation by the consolidation of backfilling soil, and is capable of protecting from the stress concentration in the block connection.

4 FIELD MEASUREMENTS

4.1 *Standard cross section diagram*

Construction of proposed reinforced soil retaining wall was carried out as a relocation project of high school. This retaining wall is 9.5 m high, and embankment 20 m high was constructed on the wall. A standard section diagram is shown in Figure 3. For

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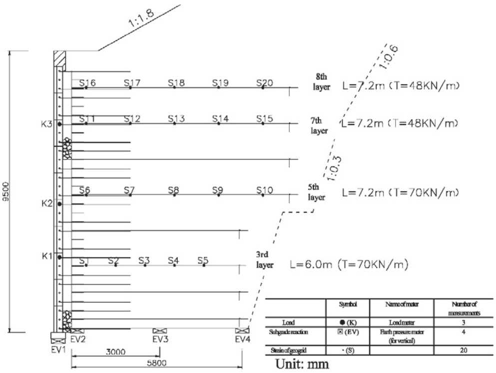

Figure 3. Standard section diagram.

the reinforced soil retaining wall used geogrids as shown in Figure 2, strain gauge, load meter, and earth pressure meter were set, and strain and load acting on each part were measured. The changes in the process of embankment on it were measured, assuming the value immediately after each meter setting, as the initial value.

4.2 *Embankment material and the subgrade*

Properties of the embankment material used at this site are shown in Table 1. The embankment materials used is the soil generated in the field. In addition, the subgrade for a reinforced soil retaining wall was improved by mixing cement material for the shallow layer.

Table 1. Properties of embankment material.

Classification	Fine fractional gravel soil
Density of soil grain ρ_s (g/cm^3)	2.639
Natural water content W_n (%)	7.92
Grading Gravel fraction 2-75 mm (%) 0	37.7
Sand fraction 75 µm-2 mm (%)	53.0
Silt fraction 5-75 µm (%)	9.3
Clay fraction 5 µm (%)	0
Maximum dry density δ_{dmax} (g/cm^3)	1.831
Optimal moisture content W_{opt}	12.99

4.3 *Outline of measurement*

(a) *Load acting on a facing wall block connection part*

Load meters (compression type) are set at the connection part between facing wall block and anti-drawing material, and the load acting on its connection part were measured. Load meters set at the facing wall block connection part are shown in Photo-6, and Photo-7.

(b) *Distribution of tension acting on the geogrid*

To measure the strain acting on the geogrid, strain gauges were set on the surface of geogrid at certain intervals. Photo-8 shows the installation situation of geogrid where strain gauges were set.

Photo-6 Load meter

Photo-7 Special metal fittings for measurements by load meter

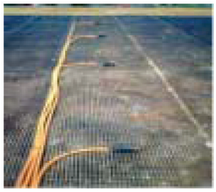

Photo-8 Strain gauge

Photo-9 Earth pressure meter in reinforced earth bottom

(c) *The reactions acting on the bottom of reinforced soil*

The reactions acting on the bottom of reinforced soil was measured by earth pressure meter. The earth pressure meter was set right below facing wall block and reinforced region at certain intervals. The set situation of earth pressure meters are shown in Photo-9.

4.4 *Result of measurements*

(a) *Load acting on a facing wall block connection part*

Time history of the load acting on the facing wall connection part (called below, load at connection part) is shown in Figure 4. The load on connection part is equal to or less than 2.0 kN/m in each point, and it can be confirmed that the loads are sufficiently smaller than a design connection strength 16 kN/m(10 kN/point). In addition, these values are about 3% of design strength of geogrid (70 kN/m) installed at the same height. It can be confirmed that all loads on connection parts increase during about 3 months after the completion of embankment construction (until the end of September, 2005). However, it can be confirmed that these values are towards a stable tendency gently after the last ten days of September, 2005.

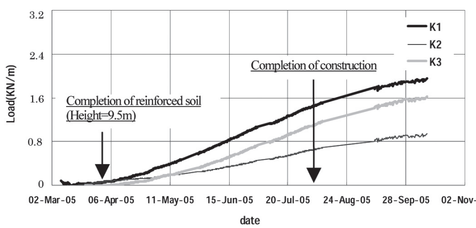

Figure 4. Time history of load in the connection part.

(b) *Distribution of tension acting on the geogrid*
Strain gauges were set on the geogrid and the strains were measured. Strain gauges were set at layer 3rd 5th 7th and 10th layers of geogrid with an interval of 1.0 m or 1.5 m. Distributions of strain of each layer are shown in Figure 5. Strain of each layer increases little with elapse of time, and shows about constant value at the first ten days of November 2005, and the embankment is thought to be stable. It can be also confirmed that the distribution of tension of geogrid shows a tendency having the peak point in the vicinity of is stable state, since the maximum subgrade reaction the major collapse line for 5th, 7th, and 8th layers. Distribution of tension shows the tendency that resembles distribution of tension of the reinforced soil wall used a soft facing wall system shown in measurements performed in the past and documents.

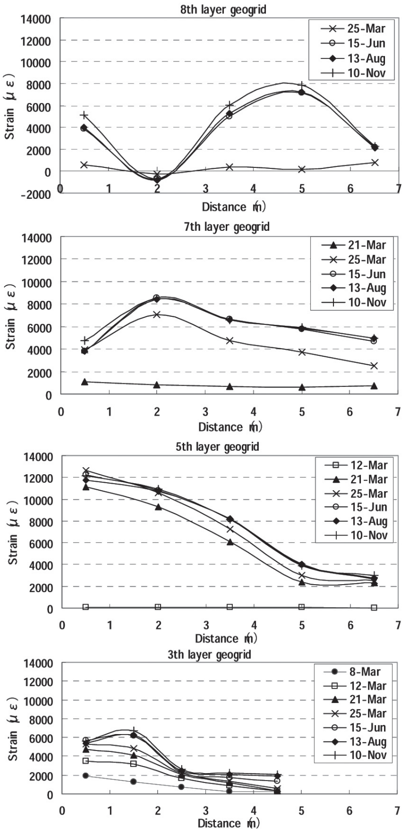

Figure 5. Distribution of strain of geogrid.

(c) *Subgrade reactions*
Time history of subgrade reaction in the reinforced soil bottom is shown in Figure 6. Subgrade reactions of all measuring points tend to increase until the completion of construction of reinforced soil retaining wall in the last ten days of March 2005. Subgrade

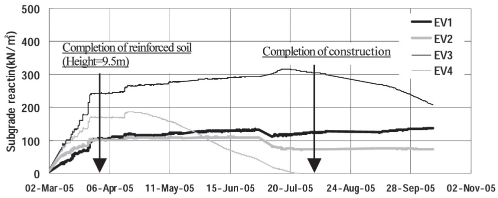

Figure 6. Time history of subgrade reaction.

reaction in the measuring point EV1 increases until the completion of construction of surcharge in the middle of July 2005. Subgrade reaction in the measuring point EV4 increases until the beginning of construction of first surcharge in the last ten days of April 2005, and then it tends to decrease. The causes of this behavior are as follows. (1) Some troubles of the earth pressure meter. (2) The earth pressure meter is overturning and abutting on the ground. (3) The 5th geogrid receives the load at the berm of cut like a hammock. (4) The reinforced soil retaining wall is eccentric in front of wall. Bearing capacity of foundation ground is stable state, since the maximum subgrade reaction is smaller than allowable bearing capacity 450 kN/m^2.

5 CONCLUSIONS

The load acting on the connection part between facing wall block and anti-drawing material is about 2.0 kN/m, and is the value much smaller than design strength of geogrid set at the same height. Therefore, earth pressure acting on the facing wall is thought to be very small. These are thought to be characteristics of structure where backfill does not contact with the facing wall. We will perform similar measurements on many fields and want to raise reliability and safety of this construction method in future.

ACKNOWLEDGEMENTS

We received great cooperation of many people in this measurement. We show gratitude to the concerned members.

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