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Stability test of the multi-anchored reinforced soil wall constructed on soft ground

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ABSTRACT: Because the degree of ground settlement that will not destabilize a reinforced soil wall with such following capability is not understood, it has been designed based on a bearing capacity safety factor identical to that for concrete retaining walls. Multi-Anchored Reinforced Soil walls are normally designed with a safety of 3, but large-scale laboratory testing has been performed in order to propose a design method that can lower the bearing capacity safety factor for this design method.

1 INTRODUCTION

Because a reinforced soil wall is a flexible structure, it can stably follow a moderate degree of ground settlement. because the degree of ground settlement that will not destabilize a reinforced soil wall with such following capability is not understood, it has been designed based on a bearing capacity safety factor identical to that for concrete walls. The current designing way of this reinforced soil wall is described at the first of this paper. The bearing capacity safety factor has been applied to 3 safety factors the current way, however, large-scale laboratory testing has been performed in order to propose a design method that can lower the bearing strength safety factor for this design method.

2 STABLE MECHANISM OF THE REINFORCED SOIL WALL

Both of the facing walls are connected to the anchor-plate by the tie-bar, and the earth pressure on the wall is supported by the pull out resistance of anchor-plate, in this way, the stability is kept. The pullout resistance of anchor-plate is based on the theory of bearing capacity for the horizontal force inside of the banking; it is shown according to the following equation.

$$Q_{pu} = c \cdot N_c + q_p \cdot N_q$$

Q_{pu} : Ultimate pull-out resistance of anchor-plate.
c : The cohesion of fill material.
q_p : The confining pressure of around the anchor-plate.
N_c, N_q : Coefficient of bearing capacity, for the pull-out resistance of anchor-plate.

In the equation (Fig. 1), if the cohesion is assumed to be constant, the pull-out resistance of anchor-plate is shown as a simple equation of confining pressure of the plate circumference that depends on the ground depth of anchor-plate and the depth dependence is shown as the earth pressure on the wall. The stability of the reinforced soil wall is univocally determined by the relationship between earth pressure on the wall and tensile strength of anchor-plate in the banking of reinforcing area with appropriate internal friction angle φ of the fill material, when a wall becomes higher, not only the earth pressure, but also the pull-out resistance increase. It is important to control the parameters c and φ suitably under this reinforcement mechanism and it is necessary that the stability of the Multi-anchored reinforced soil wall is considered in internal stability and external stability (Fig. 2).

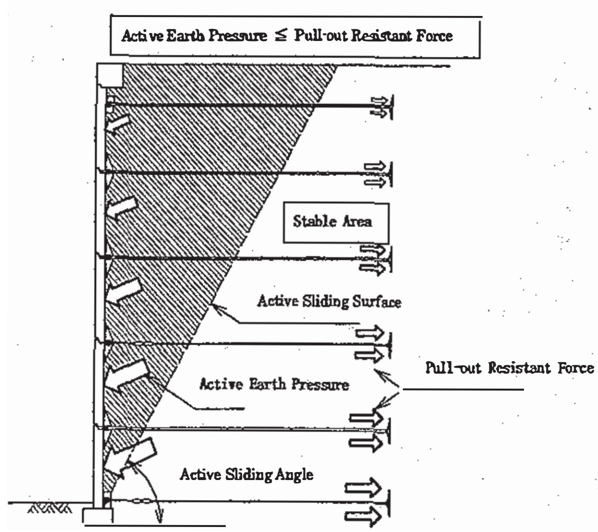

Figure 1. Examination of internal stability.

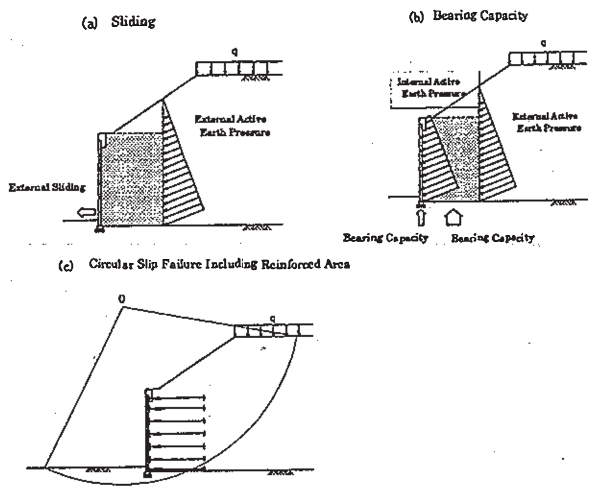

Figure 2. Examination of external stability.

In the internal stability, the reinforcing area constituted by block wall and anchor-plate group examines force for keeping the stability as reinforced soil wall and balance of resistance force. In the external stability, sliding of reinforcing area, bearing capacity of foundation ground, and circular slip failure including reinforced area.

3 BASIC POLICY OF THE DESIGN

The Multi-anchored reinforced soil wall is examined to satisfy a two-point demand of safety factor.

(1) The examination for the internal stability
1) The examination for the rupture of tie-bar
2) The examination on the pull-out resistance of anchor-plate
(2) The examination for the external stability.
1) The examination for the stability of the reinforced soil wall structure.
2) The examination for the whole stability including the reinforced soil wall structure.

In the design, it is necessary to consider sufficiently internal stability and external stability. The situation of the field is suited, and it must be considered in order to be also excellent in work- ability and economical efficiency.

Multi-anchored reinforced soil wall supports the earth pressure that affects block wall by the pull-out resistance of anchor-plate, and it is the method that constructs the banking with stabilized vertical wall. Moreover, banking region held by block wall and anchor-plate group seems to become the reinforced soil structure, because the deformation is restricted. There are two phases examination, internal stability and external stability, in the design of this method.

4 EXPERIMENT

4.1 *Outline*

The test performs by constructing a clay ground with a depth of 1.5 m inside a large soil tank with a height of 4.5 m, width of 10.0 m, and depth of 4.0 m installed at the Public Works Research Institute. An anchor type reinforced soil wall with a height of 3.0 m was constructed on top of this ground (Fig3). Kanto loam used to form the foundation ground and sandy soil uses as the banking material. The foundation ground fills loosely (wet density: ρ_t = 1.1 g/cm^3) so that the embankment and the loading would cause substantial settlement. A loading device capable of applying an overburden load q of 200 kN/m^2 that is installed on top of the embankment used to perform loading in steps equivalent to the load of 1.0 m of banking (q = 17 kN/m^2) up to the load equivalent of 8.0 m of banking (q = 136 kN/m^2) (Fig 4).

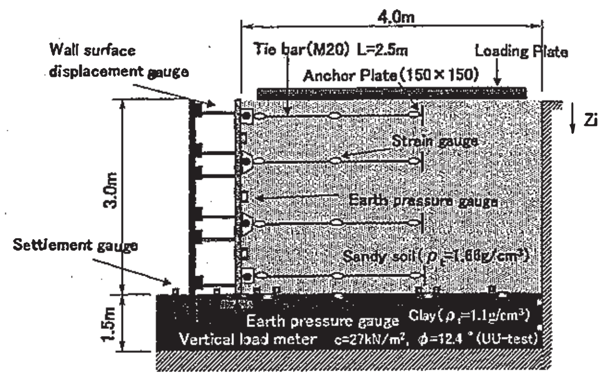

Figure 3. Outline of the experiment (cross sectional view).

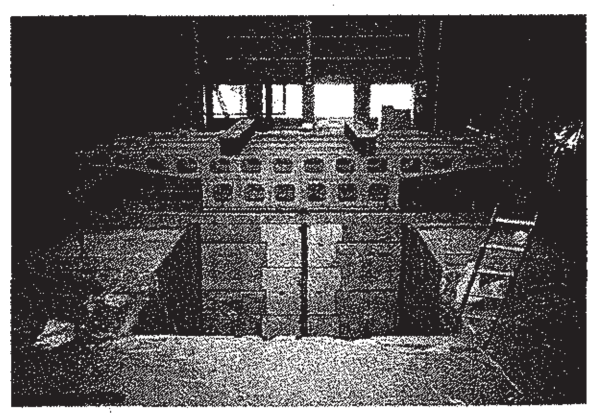

Figure 4. Test soil tank (front view).

4.2 *The prior design*

In configuration position i=1, the constructed length is insufficient. Allowable tensile stress of tie-bar and Allowable resistance force of anchor-plate have en-

Table 1. Test soil tank (Front view).

Depth	Examination for pull-out of anchor-plate			Examination of reinforcement length		
	Pull-out force	Allowable resistance force	Result	Constructed length	Design length	Result
Zi (m)	Ti (kN/ piece)	Tai (kN/ piece)		Li (m)	Lri (m)	
0.175	2.5	63.7	o	2.50	2.86	×
1.000	24.6	66.5	o	2.50	2.38	o
2.000	27.2	69.9	o	2.50	1.77	o
2.815	14.6	72.6	o	2.50	1.31	o

sured the sufficient stability. It was judged that the internal stability had been stabilized (Fig. 3 and Table 1).

4.3 *Design of the subgrade reaction*

The distribution of the subgrade reaction, when the loading is small, the part of wall base is bigger than the banking part, and it almost uniformly increases with the increase in the loading. $q=68kN/m^2$ loading stage, banking central increased excellently. The sub grade reaction compares measured value with designed value. The wall part of measured value is bigger a little than the designed value, and the banking part of measured value is a little smaller than the designed value (Fig. 5).

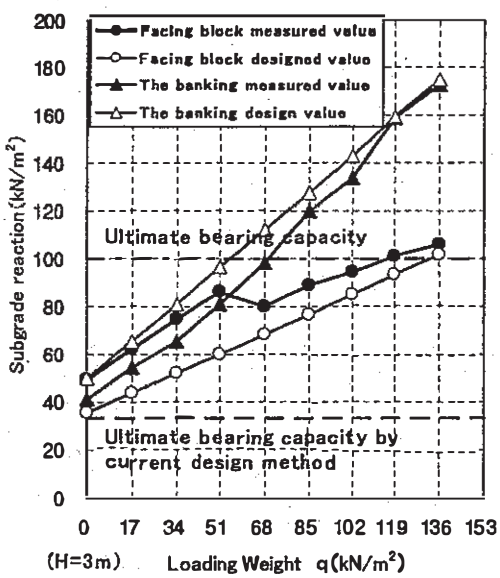

Figure 5. Designed value and measured value of the subgrade reaction.

4.4 *Results of the test*

1) Settlement and subgrade reaction of the foundation ground.

Figure 6 shows the settlement and subgrade reaction ofthe foundation ground. The loading causes a relatively large settlement of the foundation ground.

But in the reinforced soil wall, the foundation of the wall surface work do not settle very much and the area behind the reinforced section settle unequally generating the maximum deformation. The subgrade reaction increases accordingly as the loading increased.

2) Lateral displacement of the wall surface.

Figure 7 shows the lateral displacement of the wall surface. Deformation and a large lateral is placement of the wall surface occurred as it followed the settlement of the foundation ground and the overburden load. But it is not deformed to the degree that its

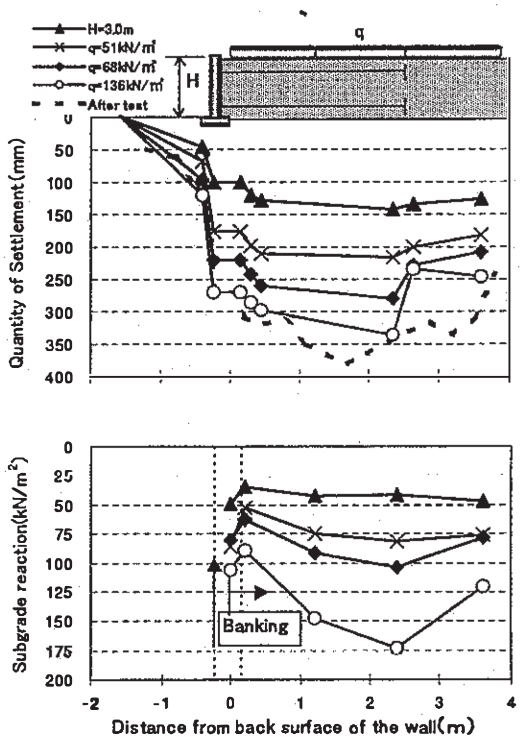

Figure 6. Distribution of settlement and subgrade reaction of the foundation ground.

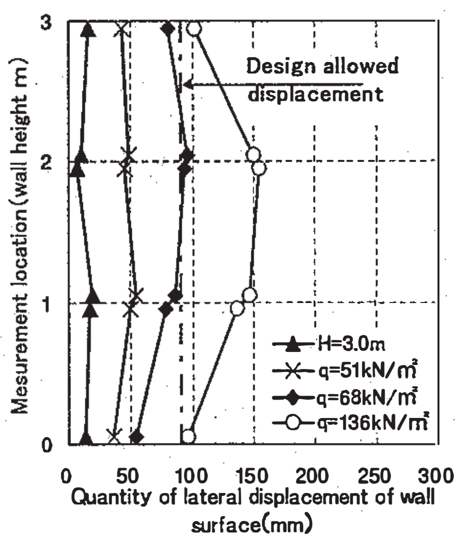

Figure 7. Distribution of lateral displacement of the wall surface.

functions are obstructed by the falling of the wall surface panel and the breakage of the reinforcement.

3) Tie-bar tensile strength and horizon earth pressure.

H=3.0m the banking end, earth pressure before the stage load testing agrees approximately with the design calculation value in the each loading stage at measurement position of H=0.5m and 2.5m wall heights, however, the H=1.5m wall height shows small value from them (Fig 8). but, Large change do not appear in $q=68kN/m^2$ loading stage of which subsidence of the ground and wall surface horizontal displacement are greatly observed. In the experimental result, tie-bar tension strength and wall surface earth pressure become a distribution that differs from the design theory in the each loading stage. However, the excessive value is not shown. Subsidence deformation for the ground and wall surface deformation do not show the behavior which internal stability causes the adverse effect.

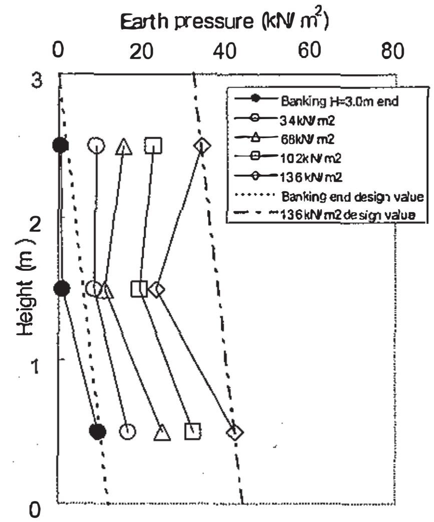

Figure 8. Tie-bar tensile strength and horizon earth pressure

5 CONCLUSIONS

1. Under the effects of the settlement of the ground, the reinforced range behaves as an integrated mass and the wall surface is deformed. The reinforced range settles more than the wall surface foundation. It is assumed that while the foundation work execute at the wall surface foundation restricted settlement, the reinforced range is untreated. For this reason the wall surface and the reinforced range should not settle unequally. It is necessary to conduct further studies of the foundation treatment method.

2. Even though the reinforced range settles and the wall surface is deformed, serious damage causing the failure of the structure does not occur.

3. The safety factor of the ground bearing strength can be reduced below the conventional level as long as it is at a level that can allow a certain degree of settlement of the reinforced soil wall and lateral displacement of the wall. This conclusion is based on the fact that although the quantity of settlement following the loading test is a maximum of 27cm at the wall surface foundation and 37cm at the center of the reinforced range. The structure continues to function properly. But further study is necessary to determine standard values from the perspective of effects on deformation of the reinforced range when it is applied at the in-situ level (Fig. 9).

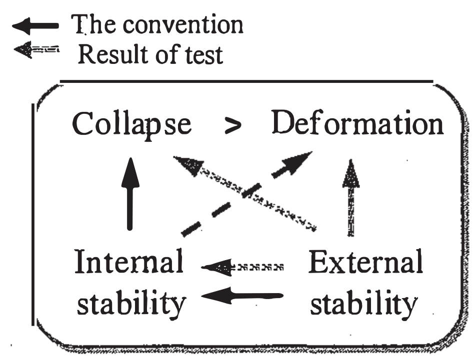

Figure 9. The relationship of structure between internal stability and external stability.

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