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A case study of hybrid reinforced geo-structure using reinforced concrete block and slope

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ABSTRACT: With the need of efficient site use retaining walls have frequently used. Of them Dry cast modular block wall (MBW), in which geogrid and concrete block are used is getting popular because of its simplicity and economical efficiency of construction. However, since this method is based on the theory of earth pressure, sands with good quality should be used. In contrast, reinforced soil slope (RSS) that the slope is less than 70° can use wider range of soil than MBW. A hybrid reinforced geo-structure might be a good alternative in view of overcoming difficulty obtaining soils with good quality as well as maximizing the efficiency of site use. This method is composed of reinforced block wall and reinforced soil slope. In this method, reinforced block wall is constructed up to a certain height vertically at ground boundary first. Reinforced soil slope is then constructed on the block wall subsequently. This paper introduces several technical points that should be taken into account in design and construction.

1 INTRODUCTION

Mechanical stabilized earth (MSE) is the geo structure that can be secure against the self weight of an embankment or external loads by restraint of lateral displacement with reinforcing elements. Of the reinforced geo-structures are the mechanically stabilized earth wall (MSEW) and the reinforced soil slope (RSS). The former uses the material of which fraction passing 74 nm sieve is less than 15% and plasticity index (PI) is less than 6, and can maximize site use efficiency because of its ability of standing almost vertically. Also, unlike any type of geo structures, the lateral earth pressure acting on the mechanically stabilized earth wall is negligible because it can be compensated by friction between soil and reinforcing element.

In contrast, the latter seems inferior to the former in site use efficiency. However, it has an advantage which the material soil can be obtained more easily, and it is eco-friendly because of its using planting treatment in order to prevent itself from scour by rainfall. In addition, the reinforced soil slope is good for settlement since it uses no concrete panels or blocks.

A new hybrid reinforced geo-structure that takes advantages from both of them has been developed and applied to a pension project in Pyung-Chang Korea. The hybrid geo-structures used in the project had dimension of 8 mm in height. This structure was composed of two substructures. One is a mechanically stabilized earth wall which was constructed vertically up to 2.4 m. The other is a reinforced soil slope which overlies on the wall and is constructed up to 5.6 m with the 70 degree of inclination.

In this paper, the results of a case study on the design and construction of a hybrid reinforced geo-structure were presented.

2 DESIGN AND CONSTRUCTION OF A HYBRID REINFORCED GEO-STRUCTURE

2.1 *Introduction*

In this paper, the hybrid reinforced geo-structure, as shown in Fig. 1, applied to the pension site preparation project carried out at Pyung-Chang Korea was examined. According to the ground exploration log, the ground was composed of stiff weathered residual soil or highly weathered rock. The height of the structure varied from 3.6 m to 10.0 m. This includes a stabilized earth wall, which was constructed at the lower with the height (h1) varying from 2.1 m to 2.7 m, and a reinforced soil slope whose height (h2) varies from 2.0 up to 7.4 m. High density polyethylene (HDPE) geogrids were used as reinforcing element.

(a) Hybrid reinforcement (Before grass germination)

(b) Hybrid reinforcement (After grass germination)

Figure 1. Hybrid reinforced geo-structure.

The design was carried out using the software, MSEW, developed by ADAMA engineering company. The procedures are as follows.

First, the height of concrete block type of stabilized earth wall (h1) and the height of a reinforced soil slope (h2) that is inclined by 20 degree to the vertical were defined. Then the required length and spacing distance of installation and tensile strength of reinforcing elements were calculated on the concrete block wall that has the height h1 + h2.

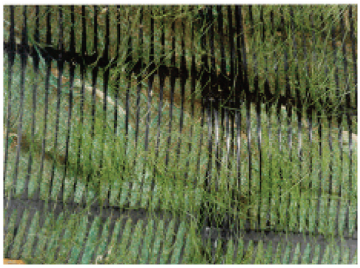
Second, for the reinforced soil slope, it was assumed to be a mechanically stabilized earth wall with 20 degree of inclination, and again the required length, spacing distance and tensile strength of reinforcing elements were calculated.

A structure was constructed as designed. A reinforced earth wall inclined by 20 degree was built on the concrete block wall. The front of the inclined reinforced earth wall was heaped with lonseng bags. And the lonseng bags were faced by geogrids shown in Fig. 2.

2.2 *Stability analysis*

Since no stability analysis on the designed hybrid geo-structure was performed at the beginning of planning it was necessary to carry out the stability analysis. For the concrete block type of reinforced earth wall, the additional stability examination was no necessary because it was assumed to be subjected to the heavier surcharge than the load by the inclined

(a) lonseng bag



(b) planted lenseng bag

Figure 2. Lonseng bag.

reinforced structure. Nevertheless, the stability examinations on translational and rotational failures for the integrated structured were required. During design procedure, each substructure was analyzed based on the convectional earth pressure theory.

The results of analysis of the translational stability, rotational stability and wedge failure on the structure that was originally designed are shown in Fig. 3

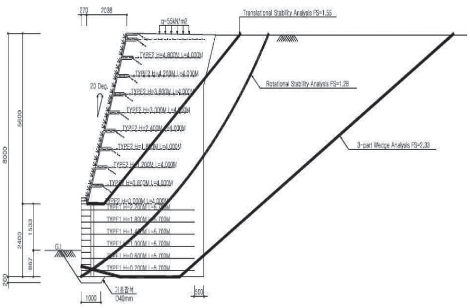


Figure 3. Failure surface of the original structure.

In this analysis, the software, Ressa (ver, 2.0), which was developed for the design and analysis of reinforced soil slope by ADAMA engineering company on the basis of FHWA standard. The safety factors for the translational and wedge failures appear to be over 1.5 while the factor of safety for rotational failure seems to be close to the value of 1.3. Fig. 4 shows the results of analysis for the structure that

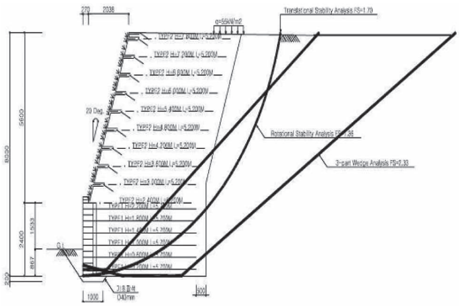


Figure 4. Failure surface of redesigned structure.

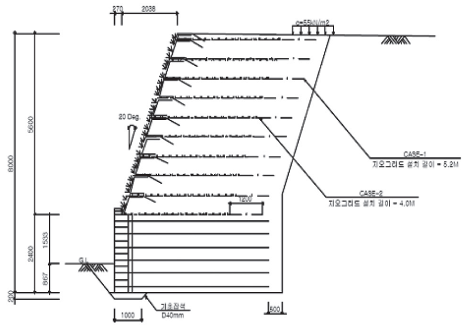


Figure 5. Comparison of drawings.

was designed applying the required height (h2) calculated in the second step of design procedure. Although the critical sliding surfaces seem to be different from the previous analysis the factors of safety appear to satisfy the standard value of 1.3. The redesigned drawing of the hybrid geo-structure from the conventional method point of view is compared with that of originally designed in Fig. 5. According to the figure, it seems that the length of reinforcing element should be installed longer by about 1.2 m when the design is performed on the basis of conventional point of view.

3 DICUSSION

According to the case study discussed above, the failure surfaces of wedge failure and translational failure seem to pass below the bottom of the structure if the ground is either stiff weathered residual soil or highly weathered rock. Therefore, alterative design approaches may be proposed as following.

(1) The required spacing distance and tensile strength on the vertical concrete block reinforced wall corresponding to the total height of a hybrid structure are estimated. During this stage, the vertical load induced by the difference between the total height (H) and the height of the reinforced wall (h1) can be calculated by converting to a uniform distributed load.
(2) The required spacing distance and tensile strength on the reinforced slope can be calculated according to FHWA standard. The slope is necessary to be designed less than 70 degrees out of consideration for planting.
(3) A hybrid reinforced geo-structure can be planned by combining with substructures that include a reinforced earth wall constructed in the lower part and a reinforced soil slope placed on the reinforced earth wall.
(4) Stability analysis, such as translational stability and rotational stability are carried out on the planed hybrid geo-structure. The length of reinforcing element at the bottom of the reinforced soil, if required, can lengthen.
(5) If the effect of ground water is worried at the backfill or the bottom of foundation the facilities for drainage may be installed.
(6) If the material used for the reinforced earth wall contains quite a little fine soil, filtering geogrid may be installed at the contact area between two sub structures. Especially, in case of flowing of ground water into this area, chimney drain should be installed.

4 CONCLUSIONS

A hybrid reinforced geo-structure in both design and construction was studied. Through the examination authors have led conclusions as follows. Furthermore, an alterative method of design and construction for such a hybrid structure was proposed.

(1) A hybrid reinforced geo-structure can be adopted for the ground which is stiffer than dense weathered residual soils. This structure can be formed by constructing a reinforced earth wall overlain by a reinforced soil slope. And the design can be accomplished by analyzing translational and rotational failures.
(2) If the soil material used for the upper substructure is finer than that for the lower substructure, a filtering geogrid should be installed at the boundary between two soils so that the finer soil is prevented from mixture. And drainage facilities should be considered in case of ground water into the structure flowing.
(3) In order to perform more effective design and construction for such a combined structure, full scale tests including monitoring may be required so that the conventional design and analysis methods can be adopted.

In conclusion, it requires further study regarding the relationship between ground condition and the length of reinforcing.

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