ACE Geosynthetics

Case History

A complex reinforced structure applied at hilly road repair case in Taiwan

Introduction

In the filed of geotechnical engineering, frequently soil nailing is applied to the application of the shallow-depth or medium-depth slope reinforcement construction at cut slope, tunnel linings construction and Tie-Back strut system for deep excavation. Its theory of mechanical mechanism is through soil nails, shotcrete and bonded surrounding soils to reach the soil improvement. The reinforced soil method is widely accepted by the filling application consuming a great quantity of fillings such as retaining wall, reinforced slope as well as the embankment; the frictional resistance from geogrids and filling materials stabilize the structure. Theoretically, both methods are taken as the reinforcement to the soil. Typically, the former is suitable for excavation slope cases and the latter is proposed for filling slope cases.

The discussed project is the combination of soil nails and ACEGrid® GG 400-I and GG 200-I. In addition, one specific geogrid and soil nail connection system is designed to eliminate pullout failure due to insufficient buried length of geogrid.

Cause of Disaster

The project was located in the County Highway 35 (5K+000), Majia Township, Pingtung County. According to the accumulated precipitation from CWB (Central Weather Bureau), in Pingtung area it was exceeding 1380mm from 7th July 2006 through 9th August 2006 after a series of storm attacks – Ewiniar, Bilis, Kaemi, Saomai and Bopha. Torrential rain damaged the subgrade of County Highway 35 (5K+000) and the traffic connection was suspended.

The site investigation observed by the design company stated that side ditches had suffered from the clogging problem for a certain while so the rainfall brought by immediate storms run over from the ditch, went down to lower places freely and converged onto the down slope. Soils on the slope toe were scoured and this scouring area was extended gradually to either side of upstream. Later, it turned the headward erosion and caused major collapse problem.

No. 8, Kung 10 Road, Yu-Shin Ind. Park, Tachia, Taichung Hsien, Taiwan, R. O. C.
Tel: 886-4-2681-8357, Fax: 886-4-2681-6266
http://www.geoace.com

The Design and Construction

It was written in the factual soil investigation report that the loose backfill layer - unit weight of 19 kN/m^3, friction angle of 28^o, cohesion of 2 kPa - extended down to 0.8 meters in depth from the top of borehole and shale layer - unit weight of 22.9 kN/m^3, friction angle of 35^o, uniaxial tension of 300 kPa - existed to the bottom of borehole from 0.8 meters deep. Considering the condition that the geology of the bottom of gully was more vulnerable than either side and the construction site is limited by terrain, the design company designed 16 to 18 meters high reinforced retaining walls. Hammering soil nails into the deep-seated failure, the rear area of the first and second stages of the retaining wall, was targeted to diminish concerns of slope stabilization resulted from inadequate buried length of geogrid in constrained site. Meanwhile, furnishing micro-piles with the foundation was essential to increase the sliding resistance of the structure. The surface and subsurface drainage system was built for waterway.

The reinforcement construction began from the bottom of destroyed slope and completed the reinforcement of lower layer before next higher layer was established. When the expected height was reached, soil nails should be served by drilling machine. (see Figure 1)

The design concept and installation procedure of the complex reinforced structure are stated as follows and showed in the flow chart (see Figure 2).

Micro-Pile and RC Foundation Slab

Mainly, micro-pile was taken as the anti-slide pile to better the structure stability while it was installed in the base of the structure. However, there were concerns of a penetration through the structure and the water infiltration. The pile head therefore was fixed with the RC slab and a penetration of pile head into the interior structure could be reduced after backfill pressure was made. As to the issue of water infiltration in the structure, 0.5 meter thick RC foundation slab was used, functioning as water resistance.

Soil Nail

Where 6-m long soil nails were driven was the weakest part under the ruined subgrade. Through the procedure of Soil Nailing - cement grouting, surrounding soils at the improvement area became solid to enhance the stabilization of the existing slope. The spacing between soil nails was 1 meter vertically and horizontally. Soil nailing method could efficiently disperse the lateral earth pressure imposed from the first and second stages of rear reinforced structure.

Wrap-Around Reinforced Structure

According to STEDwin, ACEGrid® GG 200-I and GG 400-I were proposed as the strengthened materials. The design slope of surface was 1 : 0.2 (V : H) and three-stage wrap-around reinforced structure was built from the toe of the slope. Design total height of the structure was 16 to 18 meters varied when basically the height per stage was 5 meters and the height of backfill was controlled around 0.5 meter per layer. The design buried length of geogrid was 5, 7 and 6 meters respectively for the bottom, middle and top layer. 2 meters long for the wrap-around was sufficient.

Connection System

In view of the fact that short buried distance for geogrid might cause a structural failure, one simple but wise connection system was invented to competently correct the problem. Please refer to Detail A Connection system in Figure 1, the notion of the connection system is to guide the stress of geogrid perpendicular to the forwarding direction of the route. Steel pipe attaches to the reinforced plate of soil nail through galvanized steel wire strand. Thus, once the geogrid goes around the steel pipe and gets fixed on the ground by anchor bars, the mechanics is completed. All steel components of the connection system should be galvanized as to reach the corrosion protection.

Drainage System

Poor drainage design was one of main causes to fail the structure from the design company's observation. The design company paid more attention to surface and subsurface drainage measures, thus. The surface drainage system comprised of longitudinal and latitudinal intercepting ditches could efficiently accelerate to drain heavy rainfall off. The subsurface drainage system was placing permeable materials and drainage pipes behind the reinforced structure to release the seepage.

Performance

As a result of lying in the Circum-Pacific seismic belt and the tropical marine zone, Taiwan comes with fragmental geology and succumbs to attacks of server tropical storms. Under such circumstances, after storms or torrential rain, road collapse problems in mountainous areas are occurred frequently. Apart from the restoration itself, what people concern is the protection of the nature. Through the complex reinforced construction method, bad access problems for cramped site could be overcome; simultaneously a safe and economic structure is created appropriately to maintain the residents the safety by lessening environmental impact during construction. County Highway 35 (5K+000), Majia Township, Pingtung County on the steady structure still plays a significant role for traffic after serious storm attacks during past two years.

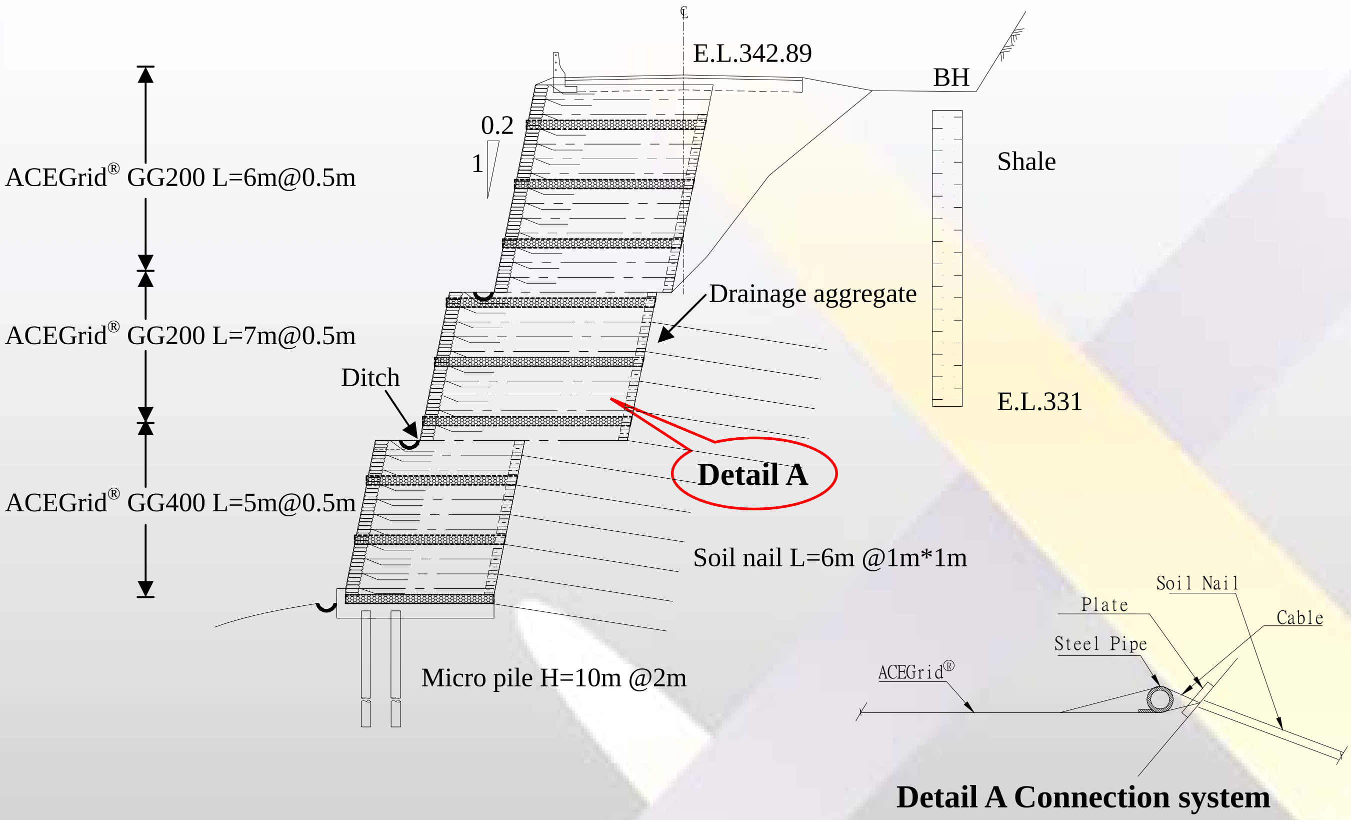

Figure 1. Cross section of design drawing

Micro-Pile Drilling and RC Foundation Slab Construction

↓

Wraparound Reinforced Structure Construction

↓

Soil Nail Construction

↓

Geogrid and Soil Nail Connection

↓

Complex Reinforced Structure Completion

Figure 2. Construction process

Figure 3. During construction (connection system)

Figure 4. After construction

Specification：ACEGrid® GG400-I,GG200-I
Quantity：12,000m^2
Owner：Pingtung County Government
Designer：Bi Shan Consulting Engineering Company
Contractor：YongXingCheng Construction Company

No. 8, Kung 10 Road, Yu-Shin Ind. Park, Tachia, Taichung Hsien, Taiwan, R. O. C.
Tel: 886-4-2681-8357, Fax: 886-4-2681-6266
http://www.geoace.com