Geosynthetics, J. Kuwano & J. Koseki (eds)

Geosynthetic-related products and applications for reinforced soil walls and steep slopes in Japan

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ABSTRACT: Typical Geosynthetics products, wall face units, and Geosynthetic reinforced soil structures in Japan are introduced and presented. Technical Committee of Geotextile Reinforced Soil Structures (TCGRSS) compiled a data base of typical Geosynthetic related products and applications in Japan, which is now available on CD. Some of them are introduced and presented in this paper. The design methods used for these applications are also explained briefly.

1 INTRODUCTION

The use of Geosynthetics reinforced soil structures in Japan has become one of the important subjects of geotechnical business. Technical Committee of Geotextile Reinforced Soil Structures (TCGRSS) in Japan was founded in 1992 for the spread and technical improvement of Geotextile reinforced soil structures. Main members of TCGRSS are Public Works Research Institute (PWRI) and private enterprises who participated in the joint research of Geotextiles with PWRI. TCGRSS compiled a data base of typical Geosynthetic related products and applications in Japan. Nine major Japanese manufactures who are members of TCGRSS participated in the compilation of the data base. More than 100 Geosynthetics, 10 wall face units and 49 applications are listed in the data base. Some of them are introduced and presented in this paper.

Main applications are for the construction of road embankments. TCGRSS published "Manual on design and execution of Geotextile reinforced soil" and the programs, where the circular slip analysis and the idea of resisting moment increase by Geotextile reinforcement are used. Geogrids made of PE, PP, PET and aramid fibers, Geowoven, nonwoven, and reinforced nowoven are used in Japan and most of them got the certificates by Public Works Research Center. Their main applications are reinforcement and drainage.

2 GEOSYNTHETICS AND RELATED PRODUCTS IN JAPAN

Geosynthetics used in Japan and compiled in the CD are as follows:

2.1 *Geogrids*

Raw materials used for Japanese Gegrids are HDPE, PP, PET fibers, glass fibers with unsaturated polyester resin, aramid fiber in PE Sheath and Vectran fibers. Most of the Geogrids in the data base have certificates of Public Works Research Center. The range of tensile Strength are from 10 kN/m to 350 kN/m measured by the method specified by the "Manual on design and execution of Geotextile reinforced soil". Typical Geogirds in Japan are shown in Table 1.

Table 1. Typical geogrids in Japan.

Raw Materials	Production/Construction	Strength (kN/m)
HDPE, PP	Extrusion	10–160
Aramid, HDPE	Extrusion with aramid fiber insert	32–180
PET+Acrylic resin or PVC	Knit + Coating	18–147
PP	Extruded tape + coating	44–150
FRP	Glass-fiber + unsaturated PET resin	49.1–350

2.2 *Nonwoven and related-products*

PET, PP, spun-bond, needle-punched nonwoven products are widely used for drainage, filtration, promotion of high water content fine soil consolidation and so forth. Japan is a mountainous country and volcanic ashes with high water contents are sometimes used as fill materials for embankment, where drainage materials such as nonwoven are sometimes more efficient than simple reinforcement by Geogrid. Very strong nonwoven Geotextiles reinforced by strong fibers can also be used for the purpose of drainage and reinforcement at the same time. Typical structure of reinforced nonwoven is shown in Photo 1. Geocomposite materials such as the combination of nowoven and hollow pipes, ribbed boards are also used for drainage.

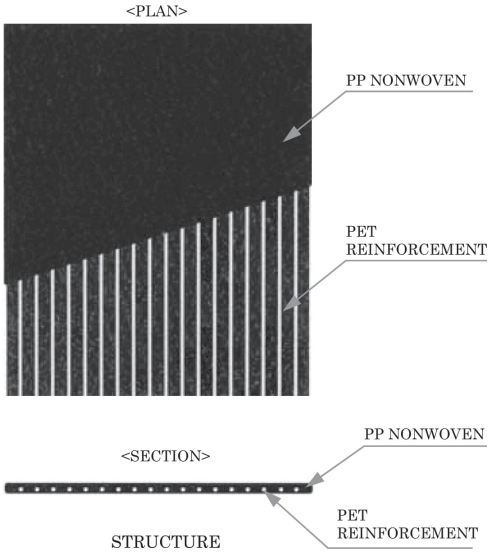

Photo 1. Reinforced nonwoven structure.

2.3 *Wall face units*

In Japan durable L shaped steel mesh wall face units are supplied by Geotextile manufacturers for the green faced reinforced soil walls. These face units are made from welded wire mesh or expanded metal and are usually anticorrosive by coating such as Zn hot dip coating, plastic resin coating and so on. Special devices to prevent deformation of the face units during compaction and the methods of joint between Geotextile and wall units are illustrated in the Photos. Concrete wall face unit is also shown.

An example of the L shaped expanded-metal plate wall face unit is shown in the Fig. 1. In Fig. 1 the vegetation mat is used for green vegetation and filter. The tie-bar is used to prevent the face from becoming steep by compaction. The waling bar gives rigidity

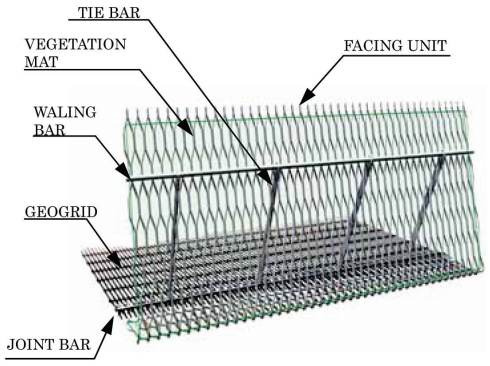

Figure 1. Facing wall unit by L-shaped expanded metal plate.

along the longitudinal direction. Geogrid and facing unit is jointed by the joint bar. Another example of facing units using welded metal mesh is shown in Fig. 2.

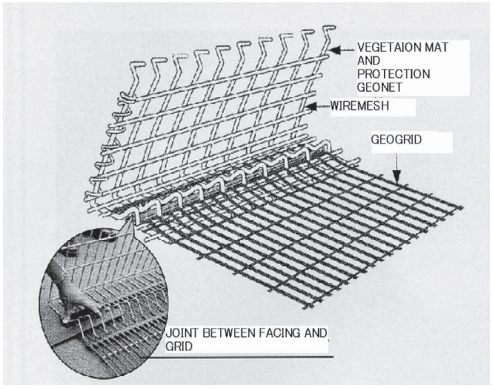

Figure 2. Facing wall unit by welded steel mesh.

An example of concrete block facing is shown in Photo 2.

Photo 2. Concrete block facing.

The required joint strengths are specified in the above-mentioned manual as 40% for flexible metal facing, 75% for concrete rigid facing with differential

settlement counter measures, and more than 100% for concrete rigid facing without the counter measures as shown in Fig. 3.

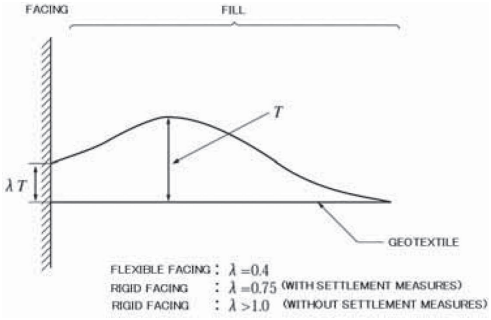

Figure 3. Tension of geotextile and necessary joint strength.

3 APPLICATIONS

Typical Geosynthetics applications are shown as follows:

Photo 3. Reinforced wall abutment.

Photo 4. Reinforced wall along a walk road.

Photo 5. Reinforced wall road in mountainous area.

Photo 6. Reinforced walls with concrete facing unit.

Photo 7. Drainage by geocomposites dark : wet by the drain water.

4 DESIGN METHOD

Technical Committee of Geotextile Reinforced Soil Structures (TCGRSS) in Japan published "Manual on design and execution of Geotextile reinforced soil" and the program, where the circular slip analysis and the idea of resisting moment increase by Geotextile reinforcement are used. Main applications are for the construction of road embankments. The design methods and the programs used for these applications are based on the manual.

Basic design equation of reinforced steep slope embankment and walls are as follows:

$$F_s = \frac{R\Sigma\{cl + (W\cos\alpha + T\sin\theta)\tan\phi + T\cos\theta\}}{R\Sigma W\sin\alpha}$$

where F_s : safety factor of reinforced soil
R : radius of circular slip
W : weight of sliced soil
c : cohesion
l : length of circular slip sliced
T : tension of Geotextile
α : the angle crossed by straight line connecting the centre of slip line cut by partial piece and vertical line
θ : the angle between the vertical line and the line connecting the intersection of Geotextile and slip-line and the slip center

As shown in Figure 4, tension of Geotextile, T, is decomposed into two components, along the slip direction and the vertical direction. The former, T $\cos\theta$, can be considered as the anchor effect against soil slip, and the latter, T sin θ, as the clamping effect by the increase of confining pressure on the slip surface. Tensile force to be generated on Geotextile shall resist against circular slip, making triangular distributed load to the direction of depth. Required reinforcement for the design safety factor is calculated, converted to earth pressure and necessary reinforcements are designed by the program developed by TCGRSS. External stability against slide, overturning, bearing capacity, and overall circular slip stability are examined, as well as the aforementioned internal stability. Following three programs are published from Public Works Research Center in Japanese. Stability against earth quake can be also examined by the programs.

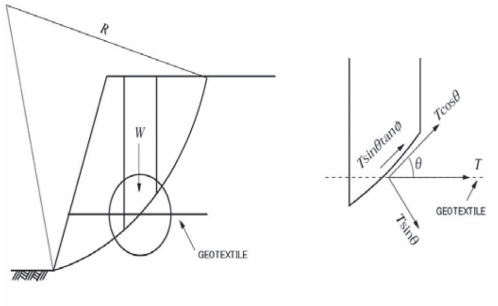

Figure 4. Reinforcement by geotextile.

- GEO-W2002 : Design system of reinforced soil wall by Geotextile reinforcement
- GEO-D2002 : Design system of reinforced embankment by tension and/or drainage reinforcement
- GEO-E2005 : Design system of gentle slope reinforced embankment by Geotextile reinforcement

5 CONCLUSIONS

Geosynthetics reinforced soil structures in Japan have come to high degree of sophistications and differentiation. Further effort for the spread and technical improvement of Geotextile reinforced soil structures need to be made by the Geosynthetics community.

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