Korean Practice of Earth Reinforcement in Combination with Other Methods

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Introduction

Traditional reinforced earth wall for Housing
- Wooden frame + Mud-ball (Mud + Chopped reeds, or Rice straw)

Modern reinforced earth technology in Korea
- First introduction; No.3 Highway in 1980
- Year 2000; 10,191 thousand m²

Reinforcing materials
- Stiff & Flexible geogrids, Geosynthetic strip type,
  Galvanized steel strip, Soil nailing, Wire mesh type
Reinforced earth embankment for the protection of castle

- Utilized the natural material; soil, rice straw, wooden pole & stick,
- Widely used in 5 century
- Prevailed in the Northeast Asia

Reinforced earth embankment for castle wall (Lee, 1998)
Old History of Reinforced Earth Application

The wall of an old house

Utilized the natural material;

- mud brick & mud ball (mud + Chopped rice straw)

Reinforced mud with chopped rice straw

The length of chopped rice straw

- inside of the wall; 3 ~ 9cm
- outside of the wall; 1 ~ 2cm
Old History of Reinforced Earth Application

Old temple (Bongjongsa Temple)

- Built in AD 672 during the Unified Sila Dynasty
- Designated No.55 on January, 1963
- The wall built by using the reinforced earth technology

Bongjongsa Temple

Located in southeast of part of Korean, Kyongbuk Province
Old History of Reinforced Earth Application

Old temple (Bongjongsa Temple)
Old History of Reinforced Earth Application

Old temple (Bongjongsa Temple)
Old History of Reinforced Earth Application

- Old temple (Bongjongsa Temple)
  - Construction of reinforced earth wall

- Wooden lattice framework
- Completed wooden framework
Old History of Reinforced Earth Application

Old temple (Bongjongsa Temple)
- The roof of Bongjongsa Temple

Completed wooden framework

Wooden lattice framework
The reinforced earth wall technology in Korea
- Retaining natural soil slope
- Embankment
- Approach embankment of bridge flyovers

The types of wall facing of reinforced earth wall
- Geosynthetic soft facing
- Hard concrete facing (Reinforced Earth Wall (REW), Modular block)
  - Precast concrete
  - Overlapping joint
  - Compressive filler
  - Various size and shapes ➔ Fit design requirement
Reinforced Earth Wall

- Yongin, Kyounggi Province
- Completion: November, 1996
- To gain the extra land

- Reinforced earth wall for apartment complex

- Belt type continuous strip
- Carbon rod: \( L = 17.5\text{cm} \), \( D = 25\text{mm or 32mm} \)
Sadang Daelim apartment complex

- Southwest part of Seoul Metropolitan
- Completion; July 1988
- Height; 16m
- Two stages of reinforced wall
- A small berm in-between the 1st staged wall and 2nd staged wall
Approach embankment for overpass bridge

Kyoungchung Highway

- Locate; Sungnam, Kyounggi Prov.
- Completion; November, 1992
- Cut to secure the earth slope against sliding failure
The Modular Block extensively used in Korea

- Side wing of an approach embankment of bridge flyovers
- Residential & office buildings
- Apartment complex and industrial factory complex in the hilly area

Various types of facial modular block made in Korea
Concrete panel type faced reinforced wall

![Graph showing constructed quantity (m², x 1,000) over years 1980 to 2000]

- Constructed quantity (m², x 1,000): 0.6, 12.773, 51.332, 95.027, 80, 65, 55

Legend:
- COL: Concrete panel type faced reinforced wall
Geosynthetic Reinforced Walls

Modular block type faced reinforced wall

[Bar chart showing the construction quantity (m² x 1,000) from 1980 to 2000, with a peak in 2000.]
Modular Block Faced Geosynthetic Rein. Walls

Modular block faced geogrid reinforced wall in Korea
Modular Block Faced Geosynthetic Rein. Walls

Approach embankment of bridge flyover
Modular Block Faced Geosynthetic Rein. Walls

Slope stability problem in the certain environment particularly

Modular block faced geosynthetic reinforced wall for apartment complex

Failure of modular block faced geosynthetic reinforced wall
Reinforced Slope with Vegetation

- Geosynthetic reinforced slope with vegetation
  - Fiber reinforced sand spray with special equipment
  - Percentage of multifiber; 0.15~0.25% by weight of sand

- Geocell System; Highway embankment & railway track
  - Filling material; gravel, sand, any types of natural soil
  - HDPE cell system; lateral confinement & facilitate drainage

- Mesh type facing slit wall with chain anchor system
Fiber reinforced slope with sand spray

Right after construction

Vegetation growth
Slope reinforcement by geocell

Right after construction

Vegetation growth
Slit reinforced slope

- Reinforcement material: galvanized metal chain
- Pullout test and field test
Types of chain reinforcement

- Chain only
- Chain + horizontal bar
- Chain + L type angle

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Reinforced Slope with Vegetation

Comparison between the laboratory pullout test and field test

Chain only

Chain + horizontal bar

Chain + L type angle

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Slit reinforced method

Right after construction

Vegetation growth
Conclusion

- The reinforcing materials in the early days: chopped rice straw, reed, and wooden stick.
- In the 1980s: reinforced earth wall, hard concrete flat panel facing.
- Since the mid 1990s: Modular block faced segmental reinforced walls.
- Recently, the geosynthetic reinforced walls with modular block facing are more common practice to extend the land around apartment complex in the hilly area.
- Geosynthetics combined with other methods are necessary to provide the services with soil reinforcement and slope protection.