Geosynthetics
Subgrade Stabilization and Base Reinforcement

Eli Cuelho, P.E.
Western Transportation Institute
Montana State University
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Geosynthetic Types

- Geotextile
- Geogrid
- Geocomposite
- Geonet
- Geomembrane
Geotextiles

- **ASTM D4439**: “A permeable geosynthetic comprised solely of textiles.”

- Woven geotextile
  - monofilament
  - multifilament
  - slit film tape

- Non-woven geotextile
  - needle punched
  - heat bonded
Geotextile: Woven Monofilament
Geotextile: Woven Multifilament
Geotextile: Woven Slit Film Tape
Geotextile: Nonwoven Needle Punched
Geotextile: Nonwoven Heat Bonded
Geogrid

- **ASTM D4439**: “A geosynthetic formed by a regular network of integrally connected elements with apertures greater than ¼ in. to allow interlocking with surrounding soil, rock, earth, and other materials to function primarily as reinforcement.”

- Categories based on junction type:
  - Extruded geogrid
  - Bonded geogrid
  - Woven geogrid
Geogrid: Biaxial Extruded or Integrally-Formed
Geogrid: Laser Welded
Geogrid: Woven
Geocomposite

• **ASTM D4439**: “A product composed of two or more materials, at least one of which is a geosynthetic.”

• Common combinations:
  – Geotextile and geonet
  – Geotextile and geogrid
  – Geotextile and drainage pipes
  – Geonet and erosion mat
Geocomposite: Geotextile/Geonet
Geocomposite: Geotextile/Pipe
Geonet

- **ASTM D4439**: “A geosynthetic consisting of integrally connected parallel sets of ribs overlying similar sets at various angles for **planar drainage** of liquids and gases.”
Geosynthetic Functions in Pavements

1) Stabilization / Reinforcement

- Base aggregate
- Wheel load support
- Subgrade Confinement
- Geosynthetic Tension

2) Separation
Geosynthetic Functions in Pavements

3) Drainage

4) Filtration
What is Stabilization?

Placement and maintenance of aggregate that serves as a stable layer for support of the remaining pavement structure.
Instabilities During Construction
Instabilities During Operating Life
Stabilization
Stabilization: Separation Function
Stabilization: Reinforcement Function

- Lateral Restraint
- Bearing Capacity Increase
- Membrane Tension Support
Full-Scale Field Study of Geosynthetics Used as Subgrade Stabilization
Background

• Problem
  • Lack of universally accepted design that uses generic geosynthetic properties
  • Understanding of which properties are most relevant

• Objective – assess performance and survivability of various geosynthetics when used as subgrade stabilization
  • Weak subgrade
  • Constructed uniformly
  • Controlled traffic
THE BIGGEST THING WE HAVE TO OFFER IS ALL THE SPACE YOU NEED

230 ACRES
4 MILES OF PAVED TEST TRACK
MONTANA’S FICKLE WEATHER

www.transcendlab.org
Test Section Layout

Direction of trafficking

<table>
<thead>
<tr>
<th>Control 1</th>
<th>WeG-1</th>
<th>WeG-2</th>
<th>IFG-3</th>
<th>CoG-4</th>
<th>IFG-5</th>
<th>WeG-6</th>
<th>WoG-7</th>
<th>WoG-8</th>
<th>WoT-9</th>
<th>NWoT-10</th>
<th>Control 2</th>
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</table>

Not to scale
Geosynthetics
Constructing Trench
Construction of Artificial Subgrade
Tilling
Moisture Control
Compaction
Pre and Post Trafficking Subgrade Strength

Composite CBR

Pre-Trafficking Composite
Post-Trafficking Composite

Test Section
Control 1
WeG-1, WeG-2, IFG-3, CoG-4, IFG-5, WeG-6, WoG-7, WoG-8, WoT-9, NWT-10, Control 2

Targeted Range
Post Trafficking Average

Control 1
WeG-1
WeG-2
IFG-3
CoG-4
IFG-5
WeG-6
WoG-7
WoG-8
WoT-9
NWT-10
Control 2
Installation of Geosynthetics
Base Course Aggregate

- Well-graded gravel
- 20 cm thick based on FHWA design
- Control sections ~100 mm of rut at 45 truck passes
- Geosynthetic sections ~100 mm rut at 455 truck passes
Grading the Base Course
Compacting the Base Course
Ready for Trafficking
Trafficking

- Total weight = 46 kips (20,860 kg)
- Speed = 10 mph (15 kph)
Pass 40
Filling in Ruts
Rut Measurements

- Differences in elevation as rut accumulates
- Two outermost wheel ruts in each test section
- Relate traffic passes to specific rut levels
- 1 truck pass = 2.2 traffic passes
Mean Rut Depth vs. $N_{add}$
Extracting Geosynthetics
Post Trafficking Measurements
Conclusions

• All geosynthetics provided improvement when compared to controls
• Welded, woven and stronger integrally formed grids performed best
• Two textiles and weaker integrally formed grid provided significantly less benefit
• Current design methods underpredicted base layer thickness for this situation
• Tensile strength in cross-machine direction plays a significant role in rut suppression
Phase II Subgrade Stabilization Study

Objective: match geosynthetic material properties to field performance
• Pooled-fund study (9 states, MT is lead)
• 17 full-scale test sections
Phase II Test Section Layout

Not to scale

Thickest base (24")
Thicker base (16")
Regular base (~12")

Thickest base (24")
Thinner base (16")
Regular base (~12")

Regular subgrade CBR=1.7
Weaker subgrade CBR=1.4
Stronger subgrade CBR=2.0
Base Reinforcement

• Improve long-term load bearing capacity
• Improve structural support
• Geosynthetics incorporated into design of road structure
• Improve roadway longevity
Application

• Tend to be lower volume roads
  • AC thickness 2 to 4 inches
  • Base thickness 8 to 16 inches
• CBR < 8
• Pavement surface distresses
  • Rutting
  • Fatigue cracking
• Reinforcement placed at bottom of base layer
Structural Contribution Based on Empirical Methods

- Traffic Benefit Ratio (TBR)
  - Comparison of equivalent pavement systems
  - Ratio of load applications in reinforced sections over load applications in unreinforced sections

- Base Course Reduction Factor (BCR)
  - Comparison of equivalent traffic capacity
  - Percent reduction in base thickness
TBR

\[ \text{TBR} = \frac{75,000}{12,500} = 6 \]

Unreinforced

\[ \text{TBR} = 4 \]

12,500 Passes

75,500 Passes

Traffic Passes
BCR

BCR = (D_{2-U} - D_{2-R})/D_{2-U}

with identical life
Benefit Results

• Requires comparative studies
• Typical TBRs from test sections
  • Geogrids: 1.5 to 70
  • Geotextiles: 1.5 to 10
• BCR
  • 22% to 50%
Geosynthetic Modeling

- Finite element model by Perkins et al. (2004)
  - Based on 2-D axisymmetric FEM contained in NCHRP Project 1-37A
  - Includes geosynthetic reinforcement

- Geosynthetic material models need constitutive properties pertinent to pavement design
  - Elastic modulus in principal strength directions (tension tests)
  - Soil-geosynthetic interaction (pullout tests)
  - In-plane Poisson’s ratio (biaxial test)
Cyclic Tension Tests

- Low-strain cyclic modulus (ASTM D7556)
Cyclic Pullout Tests

• Resilient interface shear modulus (ASTM D7499)
Biaxial Tension

• Poisson’s ratio

\[ \frac{P}{\varepsilon} \]

\[ \nu_{\text{XMD-MD}} \]
Practical Use of This Information

• Areas of weak subgrade material
  • Need for stable platform to build road
  • Maintain separation between layers
• Areas where gravel sources are limited or costly
• Low-volume roads experiencing increased truck traffic
Thank you!

Presented by:
Eli Cuelho, P.E. – Western Transportation Institute
elic@coe.montana.edu | (406) 994-7886
WesternTransportationInstitute.org