The Geosynthetic Materials Association (GMA) represents all segments of the geosynthetics industry
- Manufacturers
- Companies that test or supply material or services to the industry

GMA activities further the acceptance and use of geosynthetic materials in a variety of applications.
- Trade association
- Bimonthly magazine
- Conferences and trade show

For additional information please contact:
- Andrew Aho, Managing Director, GMA
- Phone: 651 225 6907 or 800 636 5042
- E-mail: GMATechline@ifai.com
- Website: www.gmanow.com.
Introduction to Geosynthetics

Geosynthetics, including:

- Geotextiles
- Geomembranes
- Geonets
- Geogrids
- Geocomposites
- Geosynthetic clay liners

...Are often used in combination with conventional materials, offer numerous advantages over traditional materials
Types of geosynthetics

- **Geotextiles**: permeable geosynthetic material manufactured entirely with synthetic fibers. Geotextiles are either woven (monofilament, multifilament, fibrillated yarns, or slit-film tapes) or nonwoven (needle-punched, spunbonded, or heat bonded—continuous or staple-cut fibers).

- **Geogrids**: formed by a network of tensile elements with apertures of sufficient size to interlock with surrounding fill material. Geogrids are extruded, woven (flexible), or welded.

- **Geonets**: formed by a continuous extrusion of parallel sets of polymeric ribs at acute angles to one another. When the ribs are open, relatively large apertures are formed into a netlike configuration.

- **Geomembranes**: relatively thin, low-permeability sheets of polymeric material.

- **Geosynthetic clay liners (GCLs)**: hydraulic barriers made of clay bonded to a single geosynthetic layer or to multiple geosynthetic layers.

- **Geofoam**: created by polymeric expansion process resulting in a “foam” that consists of many closed, gas-filled cells. Generally in the form of large, but extremely light, blocks that are stacked side-by-side, providing lightweight fill.

- **Geocomposites**: combination of two or more types of geosynthetics to provide the best attributes of each material. For example, geotextile/geonet, geotextile/geogrid, geotextile/geomembrane.

- **Geocells**: three-dimensional, expandable panels made from high-density polyethylene (HDPE), polyester, or another polymer material.

- **Erosion control materials**: include both degradable and nondegradable products that work with accompanying vegetation to form a biocomposite solution to erosion.
Geosynthetics In Roads & Pavements

The largest use of geosynthetics is in road applications, including separation/stabilization and asphalt overlay applications.

Providing

- **subgrade** separation,
- stabilization, drainage;
- **base course** reinforcement;
- **overlay** moisture barrier,
- stress absorption,
- reinforcement.
Life Cycle Cost Analysis of Incorporating Geosynthetic Materials in Pavement

Analysis and quantification of the benefits of geosynthetics when used in roadway applications as compared to traditional materials and construction techniques.
Six reports reviewed for analysis:


- “Going green” with textile interlayers: how to apply with pavement preservation. TenCate and FHWA Expert Task Group on Pavement Preservation.

- Study of pavement maintenance techniques used on Greenville County maintained roads, phase 2 report. *TRI/Environmental, Inc.* Austin, TX.


*All reported cost savings and other benefits when geosynthetics are used in roadways.*
Cost savings and other benefit areas:

- Agency Cost
  - Initial Construction Costs
  - Annual Maintenance Costs
- User Cost
  - Including Queue Delays, Moving Delays, Fuel Consumption & Work Zone Accident Costs
- Environmental Cost
  - Natural Resource and Energy Consumption

The agency cost, including the entire lifecycle of the project, is the focus of many cost analysis, however the other cost areas should be taken into account when analyzing the full benefit potential.
Studies show the benefits of separation/stabilization geosynthetics:

- Preserves the as built pavement structural layers indefinitely
- Prevents the loss of strength and permeability of base aggregate due to subgrade soil contamination
- Allows the use of an open, free-draining base aggregate which, by AASHTO design, offers more than twice the structural contribution of a tight, well-graded aggregate.
Studies show the benefits of separation/stabilization geosynthetics:

- Increases the structural capacity of both the subgrade and the unbound aggregate base allowing a 15-25% reduction in the structural section.

- Can more than double the design life of the pavement.

- Costs less than one inch of aggregate—a very inexpensive design safety factor.
Savings realized when geosyntheics used a separator:

- Estimated savings of $500 million each year through the use of separation/stabilization geotextiles for public agencies and private owners.

- In flexible pavements, studies suggest total pavement life cycle cost savings of up to 70% depending on design method.
Decreased rehabilitation rate and rutting

- Studies show the average needed rehabilitation for a traditional roadway occurs 5+ times in a 50 year period, while roadways where a geosynthetic is used, the rehabilitation rate drops to 2 – 3.

- Sustained reduction in rutting rate occurred with the use of geosynthetics versus increased rutting over time with traditional design methods. Rutting during the first three years may be reduced by up to 50% and by more thereafter as the base becomes contaminated by subgrade soil.
Virginia Tech – Bedford Road, VA
Flexible Road ESAL Design Curve (Dr. AL-Qadi)
Studies show the benefits of geosynthetic pavement interlayers:

- Creates a pavement **moisture barrier**.  
- Increases the strengths of both the base and subgrade.
- Become a stress absorbing interlayer to **retard reflective cracking** and the layered pavement survives several times the traffic loading before fatigue cracking begins.
- Allows the asphalt overlay may be **reduced by up to 1.5”**
- Potentially doubles the life of the pavement.
Conclusion

Each new roadway project requires analysis of the best design method for the given application, but it is shown that even in the simplest roadway designs, integration of geosynthetics offers substantial savings during the life of the roadway. Benefits apply from very weak to very firm subgrade soils and from farm-to-market to interstate highways.
Study Implications – 2012 Budget

Total VA DOT Budget
$4.764B

Spend Allocated to New Roads & Resurfacing = $4B

New Roads
$2.2B
46% of Budget
Estimated 1500 Lane Miles Annually

Resurfacing (Asphalt Overlay)
$1.8B
38% of Budget
Estimated 6500 Lane Miles Annually

Two main areas of savings: 1) Cost To Build
2) Service Life Extension (Annual Cost)
New Road Construction Comparisons

Current Practice Road Construction

Road Construction with Geosynthetics

5 ½” Reduction in Aggregate Base
New Road Savings – Cost to Build

- 5.5” reduction in aggregate base
- 1” of dense graded aggregate = $0.89/inch/sy
- Cost of 5.5” of aggregate = $4.90/sy
- Cost of 1sy of geosynthetic = $1.00/sy
- Savings = $3.90/sy
New Road Savings – Cost to Build

**Lane Mile to Square Yards**

<table>
<thead>
<tr>
<th>Width (ft)</th>
<th>Length (ft)</th>
<th>Total Area (ft²)</th>
<th>Square Yards/Lane Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>5280</td>
<td>63,360</td>
<td>7040</td>
</tr>
</tbody>
</table>

**1500 Lane Miles in 2012 Budget = 10.56 MM sy**

**10.56MM sy x $3.90 =**

$41.1 MM SAVINGS (≈0.5%)
New Road Service Life

Or, at the same initial cost, the inclusion of geosynthetic doubles the service life of new roads, from 6 to 12 years before resurfacing.
(section is geosynthetic, 14.5” AB and 5” AC)

Traditional annual lane mile cost = $29,300
With geosynthetic, annual lane mile cost = $14,650

For the 1500 new lane miles the annual savings is $22MM/year

So, take the $44.1MM savings up front, or save $22MM per year for 12 years.
Resurfacing Comparison

Current Practice Resurface Overlay

Overlay with Geosynthetic Interlayer

1 ½” Reduction in Asphalt Overlay
Resurfacing Savings – Cost to Build

• 1.5” reduction in asphalt overlay

• 1” asphalt overlay = $2.82/inch/sy

• Cost of 1.5” of asphalt = $4.23/sy

• Cost of 1sy of geosynthetic= $1.50/sy

• Savings = $2.73/sy
Resurfacing Savings – Cost to Build

Lane Mile to Square Yards

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6500 Lane Miles in 2012 Budget = 45.76 MM sy

45.76MM sy x $2.73 =

$124.9MM SAVINGS (≈7%)
Resurfacing Service Life

Or, at the same cost, the inclusion of paving interlayer doubles the service life of resurfaced asphalt pavement, from 5 to 10 years. (Section is interlayer and 2.7” overlay)

Traditional annual lane mile cost = $32,500
With interlayer annual lane mile cost = $20,900
Annual cost savings for 6500 lane miles = $75.4MM

So, take the $124.9MM savings up front or save $75.4MM per year for 10 years
Total 2012 Spending Implications

2012

Total VA DOT Budget
$4.764B

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New Roads
$2.2B
46% of Budget
Estimated 1500 Lane Miles Annually

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$1.8B
38% of Budget
Estimated 6500 Lane Miles Annually

$41.1MM UP-FRONT SAVINGS or, $22MM ANNUAL SAVINGS

$124.9MM UP-FRONT SAVINGS or, $75.4MM ANNUAL SAVINGS
Flexible Pavement Performance with and without Geosynthetics: Nine Year Follow-up

Bruce A Lacina, P.E.
Senior Engineer, Technical Services
TenCate Geosynthetics Americas
Project Description


- Approximately 1/3 mile section reinforced with Subgrade Enhancement Geotextile (proposed M-288 Class 1+).

- Portions of Marvino Lane and Country Trail and their intersection.

- Silty, clayey soil subgrade.

- Owner: City of Raleigh, NC.
Project Location

Project Location: Cornerstone Subdivision

A well graded aggregate base course (ABC) was placed directly over the geosynthetic.
Finished Roadways (2003)

HP reinforced intersection at Country Trail and Marvino Lane.

View down Country Trail reinforced with Mirafi® HP370.
Early Problems (2007)

Alligator cracking is already developing on a previously installed and unreinforced roads.

Potholes have even developed on this section of Parkstone Drive.
Recent Problems (2011)

Country Trail without Mirafi® HP370 in 2011 already had areas re-sealed and shows signs of major alligator cracking.
Reinforced / Unreinforced Comparison (2011)

Country Trail with Mirafi® HP370 in 2011, still performing very well.

Parkstone 2011: Pavement deterioration continues where the area was replaced.
Roadway Evaluation / Investigation

- Pavement Coring Evaluation, Destructive, on Country Trail Rd:
  2 Sections; 6 Cores.

- Ground Penetrating Radar (GPR), Nondestructive: Country Trail Rd.

- Falling Weight Deflectometer (FWD), Nondestructive: Intersection of Country Trail Rd & Marvino Lane.

- Surface Roughness Measurements, Nondestructive: Marvino Lane (Sect 1); South Country Trail Rd (Sect 2); North Country Trail Rd (Sect 3)
Pavement Coring Locations
Pavement Coring Results

Core Test Location

- 6
- 5
- 4
- 3
- 2
- 1

Layer Thickness (in)

- 0
- 5
- 10
- 15
- 20
- 25

HMA

ABC

Subgrade Enhancement Geotextile (Class 1+)

No Geosynthetic Reinforcement

Biaxial Geogrid with M-288 Geotextile
Ground Penetrating Radar (GPR) Test Locations: Location 1, S. Country Trail Road, with Class 1+
Location 1 GPR Results

Transition from stone to natural soils
Location 1 GPR Results

Transition from stone to natural soils
Location 1 GPR Results

Transition from stone to natural soils
Ground Penetrating Radar (GPR) Test Locations: Location 2, N. Country Trail Road, No Geosynthetic
Location 2 GPR Results

Potential start of natural soils
Location 2 GPR Results

Transition from stone to natural soils
Location 2 GPR Results

- **Asphalt**
- **Stone**
- **Fill**
- **Start of natural soils**
- **Area where road was patched**

Position (ft)

Depth (ft)
Surface Roughness Measurements (IRI) & Falling Weight Deflectometer Analysis (FWD, AREA)
Surface Roughness Measurements (MIRI)

North Carolina Department of Transportation specifies a range of acceptable IRI values of 55-70 in/mile on new construction.
## Falling Weight Deflectometer Analysis (AREA)

### Table 9 - Typical AREA Values

<table>
<thead>
<tr>
<th>Pavement</th>
<th>AREA Value, in.</th>
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</thead>
<tbody>
<tr>
<td>Rigid</td>
<td>24 - 33</td>
</tr>
<tr>
<td>Thick Flexible (&gt; 4”)</td>
<td>21 – 30</td>
</tr>
<tr>
<td>Thin Flexible (&lt; 4”)</td>
<td>16 - 21</td>
</tr>
</tbody>
</table>
Falling Weight Deflectometer Analysis (AREA)
Pavement Performance Follow-up & Conclusions

- Pavement construction was permitted by the City of Raleigh over winter provided a biaxial reinforcement geosynthetic was used over the subgrade during construction.

- Pavement construction was made easier and proceeded faster using a Subgrade Enhancement Geotextile (new proposed Class 1+).

- Pavement deterioration in unreinforced areas was evident early on, after only a few years in-service.
Pavement Performance Follow-up & Conclusions

- Showed consistent layer thickness for the HMA and ABC layers after 9 years of pavement service life in areas utilizing a Subgrade Enhancement Geotextile (new proposed Class 1+).

- Showed HUGE variability in the layer thickness for HMA and ABC layers in pavement areas without geosynthetics.

- Showed Micaceous silty / clayey / sandy subgrade soils, typical of Piedmont Geophysical Province. These subgrade soils benefit greatly from the use of a Subgrade Enhancement Geotextile.
Pavement Performance Follow-up & Conclusions

- Ground Penetrating Radar (GPR) Testing:

- The results from the Geosynthetic roadway sections display a clear separation of layers around approximately 10 to 12 inches that is consistent throughout the width of the roadway.

- The unreinforced pavement sections displayed cross sections showing no clear transition. They show a potential separation around a depth of approximately 2.2 feet, which transitions to a depth of approximately 10 to 12 inches at approximately 15 feet from the curb.
Pavement Performance Follow-up & Conclusions

- Falling Weight Deflectometer Testing:
  - The FWD deflections and subsequent calculated AREA results show that the test sections reinforced with geotextile appear to be stiffer than the unreinforced sections.
  - The reinforced sections also appear to be performing better based on the visual evaluation as well.
Surface Roughness Measurements (IRI / MIRI):

- The average IRI measurements show that the ride quality on the reinforced section of Country Trail (97.2 in/mi) is much better than the unreinforced section of Country Trail (185.4 in/mi).

- The average IRI measurements on the reinforced section on Marvino Lane (172 in/mi) shows a slight improvement over the unreinforced section of Country Trail (185.4 in/mi). This slight improvement is skewed by the presence of numerous water valves in the travel lanes on Marvino that can have a drastic effect on ride quality measurements.
SUMMARY

- Reinforcement / Stabilization geotextiles make flexible pavement construction easier and result in more consistent pavement system layer thickness (GPR, Coring).
- Reinforcement / Stabilization geotextiles increase the usable life of the roadway and can also save on construction materials (early fatigue in non reinforced areas).
- Reinforcement / Stabilization geotextiles provide a stiffer roadway cross section than comparable unreinforced pavements (FWD).
- Reinforcement / Stabilization geotextiles provide a smoother roadway surface than unreinforced pavements. Improving rolling resistance (fuel economy) and driver comfort (level of service).
Questions?

Andrew Aho, Managing Director, GMA

Phone: 651-225-6907 or 800-636-5042
E-mail: GMAtechline@ifai.com
Website: www.gmanow.com.