APPLICATIONS OF GEOTEXTILES, GEOGRIDS, AND GEOCELLS IN NORTHERN MINNESOTA

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ABSTRACT

This presentation describes four different applications of geosynthetics in the reconstruction of roads in northern Minnesota. Installations are on paved and unpaved low volume county roads, medium volume paved county roads, and a state trunk highway. County road projects use geotextiles for separation and strengthening of weak, lake deposited, subgrade soils; including a unique project at the Northwest Angle (the chimney of Minnesota) where geotextiles were used to provide a passable road during spring breakup. The state trunk highway project consists of geocell, geogrid, and geotextile sections constructed in sequence to determine which is the most cost effective. Most installations will have been in place in excess of 5 years by 2001. Maintenance benefits to date include reduced longitudinal and transverse cracking of pavements, reduced or eliminated frost heave, and reduced blading and regraveling of aggregate surfaced roads. Design benefits include reduced base course thickness requirements and improved constructability of roadbed over soft subgrades. Construction techniques used allowed for ease of placement and efficient contractor operations. Rules of thumb have been developed through practical experience to determine when and where to use geotextiles.
APPLICATIONS OF GEOSYNTHETICS IN NORTHERN MINNESOTA

Geosynthetics have been used in northern Minnesota for roadway construction ranging from gravel surface to paved road applications. They have been used as a means to stabilize poor subsoils and subgrades in order to provide a passable gravel surfaced roadway during spring breakup and also in one situation, to accomplish paving operations. Geosynthetics have also been used as part of the typical roadway design (without reducing the gravel equivalence) in several new construction projects, anticipating improved strength and reduced future maintenance activities. One research application on a state highway is using four different types of geosynthetics in a 1.6 km section to determine which will be more effective in eliminating severe longitudinal cracking. In all of the applications mentioned, the geosynthetic was not anchored, but covered with gravel of varying thickness.

The above applications occur in five northern Minnesota counties, Lake of the Woods, Polk, Roseau, Hubbard, and Beltrami. In addition to improving the constructability of the roadbed, there may be long term maintenance benefits resulting from these applications through reduction of transverse and longitudinal cracks. What we are planning to do is to monitor the longitudinal cracks on these and any future segments of geosynthetic installations through low level uncontrolled aerial photos or through the use of the Minnesota Department of Transportation’s Pavetech van. The Minnesota Department of Transportation flew low level uncontrolled aerial photos of all the segments in April, 2000. At the writing of this paper it is unknown whether this method to monitor roadway cracking will be feasible.

Lake of the Woods County, the Northwest Angle Story

The Northwest Angle portion of Lake of the Woods County is a very unique area in terms of both geography and geology. Being the northern most point in the continental United States, it was actually created by a surveying and mapping error. Geologically, the area was created when an ancient glacial lake receded, resulting lake deposited organic silts. Tremendous growth in the recreational development of the area severely damaged the existing limited road system.

Local aggregate resources are almost non-existent, and any gravel materials needed are imported from Canada. In addition, because of the environmental sensitivity of the area, any
proposed improvement must have minimal impact.

Lake of the Woods County Highway Department, with assistance from the Minnesota Department of Transportation (MnDOT), office of State Aid, developed a project proposal to stabilize and improve the road system that was efficiently constructed, minimized environmental impact, and was reasonable in cost.

The Northwest Angle system of roads is 24 km in length with no detour available. There is only one road to access the entire area. The initial project proposed to improve 8 km of the poorest sections. Construction included reshaping of the existing grade to a 9 m top width and 4% crown, placement of 9 m width pre-sewn woven geotextile with a grab tensile strength of 0.9 kN bi-directional (MnDOT type V), 200 mm thickness of stabilizing aggregate (pit run), and 75 mm of Class 5 aggregate surfacing resulting in a finished top width of 7.2 m as shown in Figure 2.

To speed construction and minimize traffic delay, geotextile was pre-sewn at the factory, re-rolled and delivered to the site. Each roll was then unrolled longitudinally, unfolded, and edges temporarily held down with wood fiber u-nails or shovels of gravel. Trucks, along with traffic, were allowed to drive on the fabric (centered on the road). Slow vehicle speed and no turning on geotextile resulted in no physical damage. Bottom dump trailers placed gravel along the centerline, while a motor grader bladed material out towards the sides. This method of placement resulted in a pre-stretching of the fabric and elimination of wrinkles. The next piece of fabric was unrolled and lapped approximately 2 m under the previous roll so that it lapped in the direction of the work. A rubber tired roller and water was used to compact the aggregate material. Using this method, approximately 1.6 km of fabric and initial aggregate surfacing could be placed each day. Cost for this construction method was approximately $50,000 per
km. Geotextile cost was $7,000 per km, aggregate subbase $29,000 per km, and aggregate base $13,000 per km.

Eventually all 24 km of roadway were improved with some modifications to the original construction method. A stronger 1.35 kN grab tensile strength fabric (MnDOT type VI) was substituted for the type V, as it was stiffer, stronger, easier to place, less susceptible to wind and had minimal increase in material costs. In addition, it was more economical to substitute the higher quality class 5 aggregate surfacing in place of the stabilizing aggregate (pit run) subbase and the overall thickness reduced to approximately 175 mm based on gravel equivalency method, where 2 mm of subbase is needed for 1 mm of base. Once completed, each section received a topping of calcium chloride to keep the aggregate from raveling. Figure 3 shows how the road is today.

![Figure 3, NWA Today](image)

The first reconstructed segments of the NWA road have been in place for over 10 years without a springtime subgrade failure. Geotextile is successfully preventing the siltly subgrade from penetrating the aggregate bases during spring thaw. Today there is over 200,000 square meters of geotextile placed at the “Angle”. Calcium Chloride and minor blading are the only maintenance activities.

**The Story of Pete**

As can happen sometimes in the most remote areas of Minnesota, Lake of the Woods County Highway Department became involved with the reconstruction of a County Road, the Corps of Engineers, and someone or something called Pete (also known as Peat). Typical construction practice called for removal of all underlying peat when widening a road for future bituminous surfacing. Disposal was normally just a matter of placing the material out to the sides. This was not acceptable to the Corps of Engineers as this was depositing fill in a wetland. The County Commissioners were notified that the project was shut down because of problems with peat.
The Commissioners then called in the engineer to find out who this “Pete” was and by what authority could this gentleman shut down our road construction. After much explaining by the engineer, the Commissioners decided to “cover up” the matter by using geotextile.

The project was redesigned to cut vertically next to each side of the existing roadbed to a depth of one meter, excavated peat temporarily stored to the side, a MnDOT type V woven geotextile placed on top of subgrade and over the existing roadbed. All seams were sewn in the field. The geotextile was approximately 18m wide to cover the subgrade, vertical cut, and existing roadbed. Excavated and graphic section shown on Figure 4.

Sand borrow was then placed on top of the geotextile to the planned grade elevation with a 1:2 inslope. The entire 13m roadtop then had a 200 mm layer of aggregate base applied. The inslopes were flattened to 1:6 by using the excavated peat that was temporarily placed to the side. Bituminous surfacing was placed the following year after grade reconstruction. In place now for over 10 years, this roadway is performing very well with no longitudinal cracks or settlement at the interface between the old roadbed and the widened sections.

To Fabric or not to Fabric, that was the Question

Because good gravel resources are scarce in Lake of the Woods County, it was decided to eliminate the placement of pit run aggregate subbase and instead use geotextile for Lake of the Woods County Road #3, a road reconstruction project in an area of poor drainage and very weak silty-clay soil. Figure 5 shows a typical section for the placement of geotextile. The project was 8 km in length with 4.8 km having the geotextile section and 3.2 km having only aggregate subbase.
The non-geotextile section had 150 mm of pit run aggregate subbase placed in addition to the 240 mm of class V aggregate base. The geotextile selected was a MnDOT type V, woven with a grab tensile strength, bi-directional of 0.9 kN. The contractor elected to sew the fabric on the prepared subgrade, as the width was approximately 12.8 m. During construction, the roadbed was constantly subjected to rain and although the center of the road was hard, the newly constructed shoulders were very soft. During construction heavy equipment was kept off of the soft shoulders. Gravel base was placed with belly dumps driving on the fabric along the road centerline. The motor grader spread the aggregate material forward and to the sides to stretch out the fabric. See figure 6.

Figure 5, Typical Geotextile Section LOW County Road #3

Figure 6, Spreading aggregate base over geotextile
Gravel base was placed in 120 mm lifts to carry construction equipment. Although it was communicated many times to keep equipment off of the soft shoulders, one errant motor grader created the 220 mm rut shown in Figure 7.

The non-fabric section was even more difficult to construct because of the wet subgrade. Additional pit run was used in some locations just to carry the gravel trucks.

The road was surfaced with 80 mm of plant mixed bituminous the following year. To try and quantify the strengthening effect of the geotextile, a falling weight deflectometer was used. Tests were taken every 30 m on both the fabric and non-fabric sections. Test results indicated similar deflections along the entire road length, leading one to believe that the section, with geotextile and less aggregate material, was as strong as the non-geotextile section. In addition, the geotextile section had a cost saving of $9,000 per km. One side benefit noticed was improved ride. The silty nature of the soils along with the wet construction season resulted in somewhat of a “rolling” ride caused by construction equipment operating on the saturated subsoils. This “roll” was much more pronounced on the non-geotextile section. This project is now over 9 years old. A recent drive-by survey indicated approximately 50 percent less transverse cracking of the bituminous pavement on the geotextile sections when compared with the non-geotextile section.

Over the years, Lake of the Woods County has placed over 1 000 000 square meters of geotextile in many applications. The cost of geotextile is less than $10,000 per km, a bargain of an insurance policy when reconstructing any road over fine-grained soils. Cost savings in reduced aggregate subbase, increased strength, protection from contamination of gravel base
from frost boils, and apparent reduction in cracking of bituminous pavements are all excellent reasons to use geotextile as part of your typical section.

**Other Projects and Test Sections**

In Roseau County approximately 240,000 m² of type V woven fabric has been used. The earliest installation was in 1992 was on County State Aid Highway 13 as shown in figure 8.

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![Figure 8, Typical Section for CSAH 13](image)

Geotextile was installed in several segments for a total length of 1.3 km of this 6.5 km project.

On County State Aid Highway 20 (10 km in length) the geotextile was installed under 175 mm of class five aggregate in 1995, fig. 9. Paving of this roadway occurred the following year. The successful paving contractor informed the county that they bid the project based on overlay prices as they had confidence in being able to pave with minimal roadway preparation due to the geotextile presence below the class 5. Transverse cracks in this segment have
varying distances between them. They range from about 75 m to 1200 m with 75 m – 100 m average spacing.

Polk County has installed both the geotextile type V and a biaxial geogrid on County State Aid Highways 58 and 59 (fig.'s 10 and 11). There is also an inplace control section. This project was constructed in 1997 and serves as a good segment for comparing non-geotextile, geotextile and geogrid segments as all have the same depth of class five aggregate and bituminous pavement. To date there is one minor transverse crack about

Figure 12, Polk Co. CSAH 59 (after 3 winter seasons)

Figure 13, Polk Co. CSAH 15 at Jct. CSAH 59, Paved in 1953, overlaid in 1974 and 1987 typical transverse and longitudinal cracking.
2 m long in one geogrid segment. There are no other visible longitudinal or transverse cracks in the geotextile, geogrid, or control section after 3 winter seasons. Generally these cracks start showing 3 – 4 years after the paving is completed. These installations total 134 000 m² of geogrid and 4000 m² of type V geotextile. Polk County is also constructing another 12.9 km aggregate base and bituminous project with geogrid on their County State Aid Highway 18, in 2000 (fig. 14).

![Diagram](image)

**Fig. 14, Polk Co. CSAH 18 typical section (yr. 2000 const.)**

In Hubbard County geogrid was used in a segment of County State Aid Highway 3 across a swamp section (fig. 15). The existing paved road was experiencing some settlements and the county was planning an overlay of the road. Through the swamp section, the existing pavement was removed and the underlying 75 mm of gravel reshaped.

![Diagram](image)

**Fig. 15, Hubbard CSAH 3 typical section**
About 20,000 m² of geogrid was laid on the reshaped gravel and 240 mm of class five gravel and 80 mm of bituminous pavement was placed over it. This was constructed in 1996 and to date, for the total length of 1.9 km, there are only 4 visible transverse and no longitudinal cracks in the surface after 4 winter seasons.

The Minnesota Department of Transportation has a research section of a variety of geosynthetic applications on Trunk Highway 72 in Beltrami County. This consists of four consecutive 400 m test sections (fig.'s 16, 17, 18, 19). The geosynthetics used are type V woven, Type VI woven, biaxial geogrid, and 200 mm geocell. The objective is to determine the most effective geosynthetic of these 4 to eliminate the severe longitudinal cracking being experienced on the majority of this highway section. Each 400 m segment was constructed in 1997 with the same typical section except for the type V geotextile. To date the geogrid visually appears to be performing the best according to a field review in the fall of 1999.
All geosynthetics used in these applications in northern Minnesota have been specified according to the 1988 or 1995 Edition of the Minnesota Department of Transportation Standard Specifications for Construction.

Typical Physical Properties of Geosynthetics:

<table>
<thead>
<tr>
<th>Property</th>
<th>MnDOT Type V Geotextile</th>
<th>MnDOT Type VI Geotextile</th>
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<tr>
<td>Grab Tensile</td>
<td>0.9 kN</td>
<td>1.4 kN</td>
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<tr>
<td>Elongation (min)</td>
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<td>15%</td>
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<td>AOS (max)</td>
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<td>0.425 mm</td>
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Geogrids

<table>
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<th>Property</th>
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<tr>
<td>Tensile CMD</td>
<td>20.43 kN/m</td>
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<tr>
<td>Weight</td>
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<tr>
<td>Aperture</td>
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</tbody>
</table>

Hubbard County will be installing two – 300 m segments on their County State Aid Highway 6 this summer, one with a biaxial geogrid and the other with type V nonwoven geotextile. Installations will be similar to the typicals discussed in this paper. These two segments are constructed in granular type soils which is typical of the soils for the entire project. This will provide a comparison between the heavy clay type soils and the granular sandy type soils for any effects on the transverse and longitudinal cracking in addition to the remainder of the constructed roadway.

**CONCLUSIONS:**

The applications of geosynthetics generally have been used in situations where there is some concern for soil stabilization or poor soil conditions. The authors have found that it is very cost effective to use a somewhat stiffer geotextile (grab tensile strength bi-directional of 1.4 kN) because of the added benefits with minimal additional material costs. The type VI geotextile with 1.4kN tensile strength only costs an additional $0.10 per m² versus the type V geotextile (0.9 kN tensile strength). Also, by allowing the contractor to carefully drive over placed fabric and sewing rolls longitudinally, we greatly reduce the placement cost. To expedite placement of geotextile and to maintain seam quality, we recommend factory sewing if overall fabric widths are 9 meters or less.
There are also field test results that indicate geosynthetics have strengthening effects that could reduce the thickness of the gravel base course while maintaining the original designed load carrying capacity. Our conclusion from actual field experiences with geosynthetics is that they have potential long term benefits when applied as an integral part of the design without reducing the gravel or bituminous thickness.

Long term benefits observed are reduced maintenance of transverse and longitudinal cracking and stronger road to resist rutting which could offer more economical future preservation type fixes such as thin (40mm) overlays or seal coats rather than the traditional 80mm overlays. There is also the benefit of having a gravel road somewhat immune to frost boil action during spring breakup which results in an all weather year around road.

Typical contract costs for furnishing and installing a Type VI woven geotextile is $10,000 per kilometer. This initial cost is small compared to the opportunity to reduce subbase, improve constructability of aggregate base courses, reduced pavement rutting and cracking, and protection of gravel bases from frost boil migration and contamination.

The authors plan to continue to monitor all these and future applications of geosynthetics for benefits and unforeseen problems. Also the documentation of any progression of transverse and longitudinal cracking would be included. The more data gathered from constructed projects the more it will help us in future designs of roadways for longer service life in northern Minnesota.