the additional required pavement thickness is (1.6 - 0.8) (23 cm) = 18 cm. A greater overlay thickness of 33 cm is recommended according to the CBR methodology (12).

CONCLUSIONS

Three main conclusions can be drawn from the work described in this paper:

1. An economical rehabilitation program for low-volume urban roads should be based on actual performance under local conditions. Overlay requirements based on subgrade strain criteria proved to be practical and more economical than CBR and are consistent with previous local experience in designing and maintaining these roads.
2. NDT appears to be a useful and economical procedure for determining the engineering properties of the pavement and subgrade system. Where heterogeneous construction methods have been used in the past, NDT should be supplemented by some destructive testing. The approximate cost of the destructive tests was budgeted at 10 percent of the NDT design and engineering costs.
3. The design charts and relations between subgrade modulus and CBR presented in this paper can easily be programmed into desk calculators. In this way, the pavement and subgrade moduli and the CBR can quickly be determined after NDT. This process is very useful in correlating the NDT results with actual pavement conditions.

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Use of Geotextiles in County Road Construction

WAYNE A. FINGALSON

The experience of the Wright County Highway Department in Minnesota in the use of geotextiles as part of county road construction is described. This is essentially a technical case study for two projects that specified geotextiles for embankment stabilization. Both projects involved roadbed construction over unstable, boggy ground with peat thicknesses up to 12 ft. Engineering fabric was specified for these areas in lieu of muck excavation. A woven polypropylene filter fabric was used for both projects. The use of the fabric, which was quite successful, resulted in a savings of about $75 000 over conventional muck excavation. The geotextile specifications used for the projects are discussed, and a section dealing with the construction experience is also included. The stabilization abilities of the engineering filter fabric used were impressive. Geotextiles appear to be a cost-effective aid in constructing embankments over soils that have low load-carrying capacity.

The experience of Wright County, Minnesota, in the use of geotextiles as part of county road construction is described. This is essentially a technical case study for two Wright County Highway Department projects that specified geotextiles for embankment stabilization.

BACKGROUND INFORMATION AND PROJECT DESIGN DATA

Wright County is one of several counties that constitute a ring adjacent to the Minneapolis and St. Paul metropolitan area. It is located 25 miles northwest of the Twin City area (Figure 1). The Wright County Highway Department for the past few years has had a construction program of $2-4 million annually.

One of the projects included in the County's 1979 construction program was a 4-mile grading job on Wright County Road 111 in northern Wright County (CP 77-C111-121, Figure 2). The subgrade soils on this project had a design Hveem stabilometer (AASHTO T190) R-value of 12. The R-value reflects a soil's resistance to lateral deformation under a vertical loading (1, p. 2). The traffic on CR-111, which is adjacent to Lake Maria State Park, consists primarily of recreational and local vehicles; there is very little heavy-truck traffic. This is reflected in the 20-year design sigma N18 of 10 168. Sigma N18 is the total number of equivalent 18-kip single-axle load applications anticipated or experienced to date by a pavement during the design period (1, p. 2).

This project involved roadbed construction in two locations over unstable, peaty soils, saturated in some places to a depth of 3.5 ft. Borings indicated peat depths to 11 ft.

ROAD STABILIZATION ANALYSIS FOR CR-111

The area of most concern was the portion of the project shown in Figure 3. As this plan view illustrates, a new alignment was required along the east side of North Lake. The soil in the area between stations 109+00 and 121+00 was found to be very unstable, plastic material. Borings indicated peat layers varying from 4 to 11 ft in this area. Resistance soundings, which are used as supplemental information by the Minnesota Department of Transportation (MnDOT) (2, p. 5), were taken throughout this area with a 35-lb hammer and 0.5-in rods. A typical set of soundings (taken at station 119+00, 35 ft left) is as follows:

Depth (ft)	Blows/Foot
0-10	Push
10-11	8
11-12	10
12-13	17
13-14	19
14-15	15
15-16	13
16-17	17
17-18	17
18-19	16
19-20	18

Time constraints did not allow any further testing such as compression tests, vane shear, or cone penetrometer.

It appeared to us initially that we would be adding a muck excavation item to this construction plan, which would allow for extensive removal of this unstable material. However, we decided to look into the feasibility of using engineering fabric, about which we had been hearing more and more. Our thought was that this fabric could provide tensile reinforcement for the roadbed. A literature search was conducted and contacts were made with company representatives and engineers who had used geotextiles in similar applications. The information gained in this effort convinced us that engineering fabric should provide us with the added stabilization needed for the roadway construction.

DEVELOPMENT OF SPECIFICATIONS FOR GEOTEXTILES

Specifying the construction fabric proved to be difficult (and confusing at times). Although several state transportation departments and the U.S. Army Corps of Engineers had developed both specifications and fabric test methods, there was no real consensus among them. Many related only to drainage and erosion control applications. The MnDOT experience with fabrics had been for the most part limited to

Figure 1. Location of Wright County.

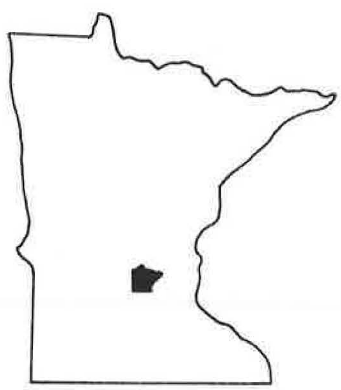


Figure 2. Location of projects within Wright County.

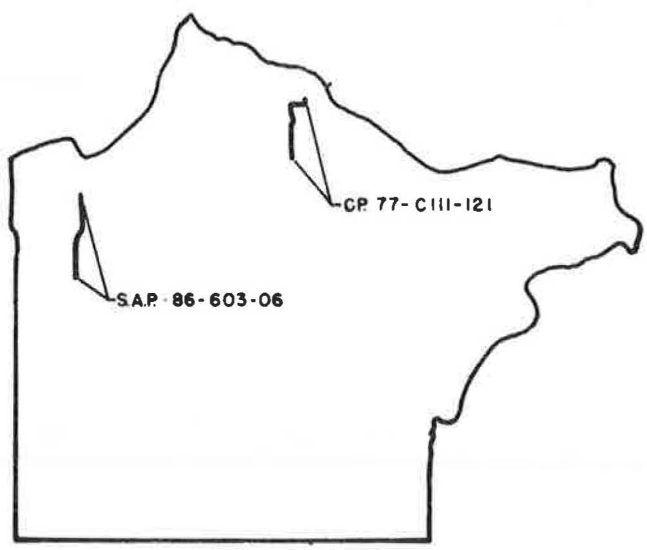


Figure 3. Plan view of CR-111 (North Lake).

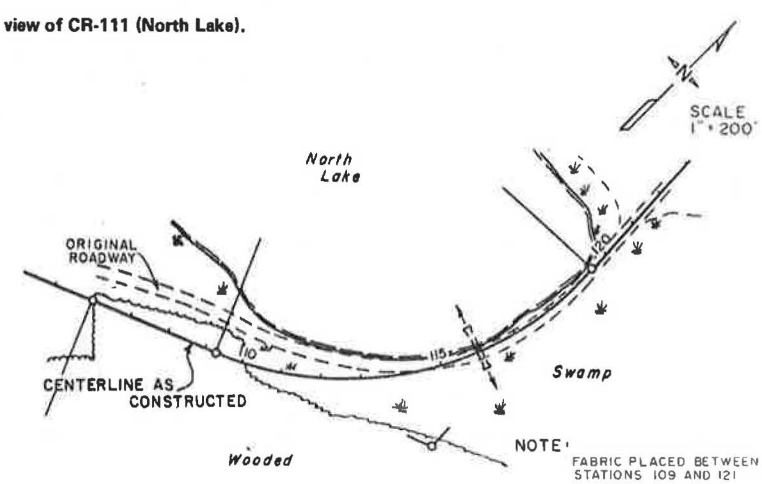
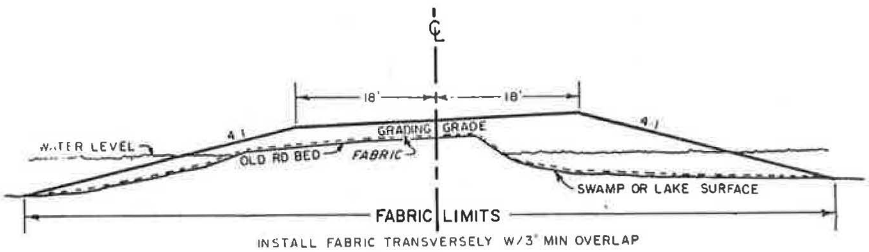


Figure 4. Typical engineering filter fabric section, CP 77-C111-121.



their use in drainage applications. However, they had used fabric for stabilization in a few smaller applications than that which we were planning.

Several well-known brand names of engineering filter fabric were selected for inclusion in the bid specifications for the project. Criteria for inclusion in the list were strength and stretching characteristics, weight, permeability, etc. The development of the fabric specifications was certainly not an exact science because of all the unknown variables. Perhaps lower fabric strength characteristics would have worked at some of the locations, but it is important to know that this project was not set up as a research project, so for a smaller initial cost difference, our specifications seemed proper. However, since the fabric seemed to be tested to its limit due to the mud-wave displacement, it appears that we did not overdesign the fabric. The fabric ultimately selected by the contractor (E.T. Niehaus Construction of Grove City, Minnesota) was Mirafi 500X, a woven polypropylene filter fabric manufactured by the Celanese Corporation.

Those portions of the project specifications dealing with construction procedures (which were adhered to) and payment are as follows:

S-15.2 Construction Procedures

(a) Clearing Prior to Placement of Fabric

Clearing shall be performed to remove any sharp objects which may puncture the fabric. All trees and brush shall be cut off flush with the ground surface or lake bottom. The root structure below the ground surface shall not be disturbed. Grass and weeds shall not be cut. The mat of grasses and weeds as well as the root system act as a "crust" which provides tensile strength to the upper soil stratum upon which the road embankment must rest.

(b) Material Placement

Engineering Filter Fabric shall be placed transversely (perpendicular to road centerline) to the roadway as shown in the plans. Care should be taken to overlap the filter fabric material at least 3 ft, as prescribed by fabric manufacturers. In no case shall vehicles be allowed to drive on the filter fabric. Placement of granular material (see S-10.7) over the fabric shall be by end dumping. At least one foot of granular material shall be placed between truck tires and fabric before the granular material is completed.

The granular material should be spread thicker than is required and the surplus shaved as construction proceeds; this provides a thicker layer of material to support dump-truck wheel loads near the head end of the area where compaction levels are the lowest. If the fabric is damaged during installation, the granular material around the rupture shall be removed and the damaged area covered with a patch of Engineering Filter Fabric using a 3 ft overlap.

(c) Maintenance

Maintenance in the form of surface blading and some additional fill (granular borrow) will be required as the underlying soils consolidate.

In the event a vehicle should become stuck in the fill, any load in the vehicle should be removed and mats placed under the wheels to reduce further rutting. Any ruts shall be filled with granular material.

If localized soft spots develop in the embankment, either as it is built, or after completion, Engineering Filter Fabric shall be spread over an area at least twice the diameter of the soft spot and covered with a foot of granular materials.

S-15.3 Payment

Measurement will be made on the basis of the area covered with Engineering Filter Fabric, as specified. Payment will be made under Item 0105.502 - Engineering Filter Fabric Treatment, at the Contract price per square yard, which price shall be compensation in full for all costs relative to preparing the subgrade for and placing the fabric in-place as specified, except that work for which other contract items have been specifically provided.

CONSTRUCTION DISCUSSION

The contract quantity for filter fabric treatment on CP 77-C111-121 was 19 234 yd^2. The bid price (to furnish and install) of Niehaus Construction was $1.50/$yd^2$. This cost reflected a savings of about $60 000 over conventional muck excavation.

The Mirafi 500X used on the project was packaged on rolls 12.5 ft wide. Roll length was 432 ft and roll weight was 175 lb. The fabric rolls could be conveniently handled by two workers.

Work was started on filter fabric placement along North Lake on September 6, 1979. It is worth noting that there was a failure of the in-place roadway (before the fabric was placed) after four empty T.S. 24 scrapers traveled to a cut area on the north side of North Lake. The contractor had hoped to use this section as a haul road. When a scraper had to be towed from the area, the contractor waited until the fabric and 2-7 ft of granular borrow had been placed. After fabric installation and compaction, there were no noticeable wheel ruts from the many passes by heaping scrapers.

Figure 4 shows the typical section of fabric placement on this project. The average width of fabric placement between stations 109+00 and 121+00 was 87 ft. The contractor began by overlapping the fabric the specified 3 ft. However, when fill was placed, it was difficult to maintain the required overlap due to the shifting of the soft subgrade

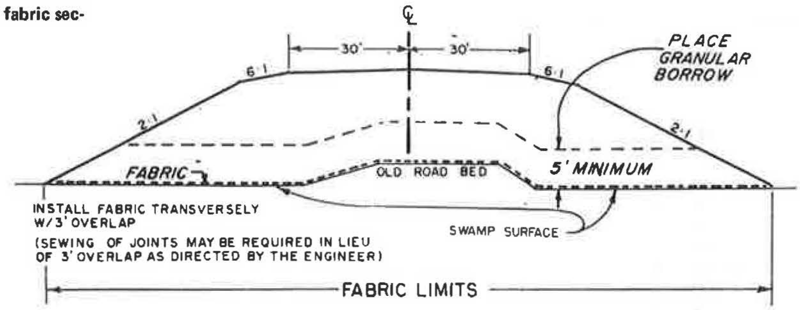


Figure 5. Typical engineering filter fabric section, SAP 86-603-06.

material. The contractor then began to overlap approximately 6 ft to allow for fabric slippage. This used up too much fabric and became quite expensive. It was then decided to sew the sections together with a gas-powered sewing machine. We had advised the contractor at the preconstruction conference that this might be necessary, so arrangements had been made to have such a machine available. The nylon thread used worked well, but double and triple stitching were required. Seams that were single stitched began to burst due to the mud-wave displacement. Any open seams were patched with fabric. Five sections of fabric were sewn together and then pulled onto swamp prior to fill placement. This procedure worked quite well for the contractor.

About 8 ft of granular fill was placed over fabric on this project. The granular material probably decreases the stresses by distributing the load over a large area. The fabric used here provided the tensile reinforcement to carry the excess bearing pressure. The compaction in the areas where the fabric was used was excellent. The survey crew complained that the stakes kept breaking during bluetopping due to the solid surface even after the many applications of loaded scrapers.

In 1980, CR-111 was completed with the addition of 6 in of aggregate base and 3 in of bituminous surfacing. No noticeable settlement was observed in the spring of 1980. Any settlement that would have occurred in the fabric areas would probably have been instantaneous at the time the fill was placed over the geotextile material. The roadway as of December 1982 looked excellent and there were no signs of settlement or distress.

SUMMARY OF SECOND PROJECT SPECIFYING GEOTEXTILES

A second Wright County project where geotextiles were used in 1980 was State Aid Project 86-603-06. This grading project on CSAH 3 (SAP 86-603-06, Figure 2) called for 7100 yd² of engineering filter fabric treatment. This roadway carries heavier traffic than CR-111 as reflected in the 20-year design sigma N18 of 196 000. Figure 5 illustrates the typical section for the project's filter fabric area. A typical sounding shows the swamp bottom as shown to be about 7-8 ft of material that had a sounding of 3-9 blows/foot and 8-13 ft of material that had 12-14 blows/foot.

The fabric specifications used on CP 77-C111-121 were also used on SAP 86-603-06. The unit bid price (to furnish and install) for the fabric item was again $1.50/yd². The contractor (Minnerath Construction Company of Cold Spring, Minnesota) also chose Mirafi 500X as the fabric. The only real difference on this project was that Minnerath decided to use the sewing machine initially after we described our previous year's experience.

This project had 12-13 ft of fill over the fabric section on the top of the roadbed and a maximum of 16 ft over the inslope areas. Again there was no noticeable settlement in this area in the spring of 1981. During the summer of 1981, this segment of CSAH 3 received the addition of 6 in of aggregate base and 3 in of bituminous surfacing. This roadway as of December 1982 also looked excellent and showed no signs of settlement or distress.

Both projects required culvert placements in areas treated with fabric. This worked very well by trenching through the fabric with a backhoe after sufficient granular fill had been placed over fabric. Fabric was then used as a liner in the trench; adequate overlap was allowed.

CONCLUSION

Wright County is very impressed with the stabilization abilities of the geotextiles used on the two described projects. Both project contractors were very suspicious about the use of the fabric on the two projects prior to construction activities. However, they indicated after they had used the fabric that they were surprised by its reinforcement abilities. Geotextiles appear to be a cost-effective aid in constructing embankments over soils that have low load-carrying capacity.

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