FIELD SCALE TRIALS OF A GEOSYNTHETIC CAPILLARY BREAK

A. Meier, I.R. Fleming, S.L. Barbour,  Department of Civil & Geological Engineering, Univ. of Saskatchewan, 57 Campus Drive, Saskatoon, Canada, S7N 5A9

B. Ayres and M. O’Kane.  O’Kane Consultants Inc., 2312 Arlington Ave., Saskatoon, SK., S7J 3L3

ABSTRACT

The environmental loading from acid-generating mine tailings can be decreased by reducing the net percolation and/or oxygen diffusion into the underlying waste. Engineered soil cover systems incorporating a capillary break are often used to achieve this effect. This paper describes ongoing work which is being carried out to evaluate the use of a geosynthetic product; geosynthetic capillary break (GCB) to develop a capillary barrier effect within a cover system. Column testing and numerical modelling reported by Park and Fleming (2005a) confirmed that such a system could be beneficial as part of an engineered cover system (Park and Fleming, 2005b).

This paper will present the design and instrumentation of full-scale test covers constructed at the tailings management facility at Hudson Bay Mining and Smelting, Flin Flon, Manitoba. Field results from the first several months of monitoring will be presented, demonstrating that the geosynthetic capillary break (GCB) improves the performance of the cover system.

1. INTRODUCTION

The design of reclamation soil covers to control acid mine drainage from waste rock or tailings requires a textural contrast in adjacent soil layers in order to create a zone of high saturation. A conventional soil cover system of this type utilizes coarser and finer grained soils placed by conventional construction equipment. At many mine sites the required volumes of these material types are unavailable. In addition, the placement of these relatively thin soil layers requires a level of construction control which prevents the use of existing mining equipment.

A geosynthetic product, referred to as a geosynthetic capillary break (GCB), has been recently developed to provide a ‘capillary break’ similar to that produced by placed soil layers. This new GCB is composed of a finely ground rock powder needle-punched between an underlying thick nonwoven geotextile and a lightweight cover geotextile in a manufacturing process very similar to that of a geosynthetic clay liner (GCL). The goal of this system is to create a capillary break simply by rolling out the manufactured GCB over top of the tailings. The GCB layer would be protected by an upper soil layer which also serves as a rooting layer for vegetation.
The Hudson Bay Mining and Smelting (HBM&S) tailings facility in Flin Flon Manitoba presents an ideal location for testing of the new GCB. HBM&S operates a large tailings facility; however, there is a limited supply of cover soil material in the surrounding area.

2. BACKGROUND

Characterization of the GCB was completed in a previous MSc program. (Park, 2005) with the performance of a hand-constructed model GCB demonstrated through the use of column tests. It was found that the GCB greatly reduces the amount of water entering the tailings when utilized in a cover system. The GCB for the column tests was composed of the same various components of geotextile and rock flour but were simply laid out without needle-punching. The GCB used in the field scale test plots is an actual prototype produced in a limited production run of 2,500 m² at a geosynthetics manufacturing facility in eastern Canada. The effect of needle-punching in the manufacturing process may influence the performance of the cover system involving the GCB, for example as a result of a decrease in the sharp textural contrast relative to the hand-constructed model of the GCB.

3. SITE DESCRIPTION

The test plots were constructed in October of 2006 at the tailings management facility of Hudson Bay Mining and Smelting (HBM&S) in Flin Flon Manitoba in an area in which the tailings are relatively flat. The area in which the plots were constructed has received no new tailings since 2003.

<table>
<thead>
<tr>
<th>Test Plot</th>
<th>Cover System Description</th>
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<tbody>
<tr>
<td>A</td>
<td>GCB covered by 1m cover soil</td>
</tr>
<tr>
<td>B</td>
<td>1 m cover soil</td>
</tr>
<tr>
<td>C</td>
<td>GCB covered 30 cm topsoil</td>
</tr>
<tr>
<td>D</td>
<td>15cm of sand covered with 1 m cover soil</td>
</tr>
<tr>
<td>E</td>
<td>Bare Tailings (Control Plot)</td>
</tr>
</tbody>
</table>

4. MONITORING SYSTEM DESIGN AND DESCRIPTION

Figure 1 shows a plan view of the test plots and the key components of the instrumentation. Key components of the instrumentation include an automated meteorological station, *in-situ* monitoring nests, and spatial monitoring locations for moisture content and gas concentration.

4.1 Climate Conditions

A fully automated meteorological (MET) station was installed on Plot B. The station is equipped to measure rainfall, air temperature, wind speed, relative humidity, and net radiation. The MET station is set to take readings every hour. Daily averages, maximum, and minimum values will then be calculated.

4.2 *In Situ* Monitoring

*In situ* monitoring is conducted on a continuous basis for water content, soil suction, temperature, and gas concentration. It is anticipated that Guelph Permeameter testing will be undertaken to describe the hydraulic conductivity of the cover material.

4.2.1 Thermal Conductivity and Automated Soil Moisture/Salinity Sensors

Thermal conductivity sensors measure *in situ* suction and temperature. Two nests were installed in the centre of plots A and B (1m of cover overlying the GCB and 1m of cover soil only). The sensors were installed at locations just below and above the GCB, as well as throughout the cover soil.

Automated soil moisture/salinity sensors are used for real time monitoring of soil moisture and salinity. The sensors utilize Frequency Domain Reflectometry (FDR) for both the moisture and salinity measurements. As with the thermal conductivity sensors, soil moisture sensor nests were installed in the centre of plots A and B. The location of the sensors corresponds with the suction sensors.
Both the thermal conductivity and the soil moisture sensors will be used in the development of field soil water characteristic curves (SWCC). All of the sensors are connected to a data acquisition system (DAS) and are programmed to take readings every three hours.

4.2.2 Portable Soil Moisture Probe

The Diviner 2000® is a portable soil moisture probe. The probe is connected to a portable display unit which records moisture content at 10 cm intervals along a vertical profile up to 160cm deep. The system uses Frequency Domain Reflectometry (FDR) to obtain moisture readings throughout the profile.

Portable soil moisture probe access tubes were installed in three locations on each of the five test plots. These tubes will allow for a vertical profile of the water content through each of the plots. Lateral access tubes were also installed running through the plots approximately 30cm above the cover/tailings interface. The lateral tubes will be used to obtain a horizontal profile of water content through the plots and will assist in identifying any edge affects.
4.2.3 Field Saturated Hydraulic Conductivity

It is anticipated that field saturated hydraulic conductivity will be evaluated using a Guelph Permeameter in the summer of 2006 and 2007. This will allow for the monitoring of changes in the hydraulic conductivity over time.

4.3 Gas Sampling Ports

Gas sampling ports will be installed in the summer of 2006. The location of the ports will coincide with the depths of the suction and automated moisture sensors. The ports will allow for gas samples to be taken to monitor the concentration of oxygen and carbon dioxide at the various depths. This information will be used to evaluate the GCB as an oxygen-limiting barrier.

4.4 Additional Field Monitoring

Snow surveys were also completed in the winter and spring of 2006. These are vital in the evaluation of a water balance as a significant portion of the precipitation comes from snow.

5. DISCUSSION

The test plots were constructed in October of 2005. Data has been collected from the fall of 2005 to the spring of 2006. The DAS and MET station data has been collected once a month since November 2005. The frequency of data collection was undertaken to avoid large gaps in data if problems occurred with the sensors or DAS.

5.1 In situ Water Content

The readings from the portable soil moisture probe for plots A, B, and D can be seen in Figures 2 through 4. The readings contain one set from the fall of 2005 and two from the spring of 2006 after spring melt. It can be observed that the moisture profile in the plot containing the GCB and the plot with the conventional sand capillary break are comparable. The moisture content of the cover soil immediately above the capillary break in both plots average between 20 and 25%, whereas the moisture content in the lowermost cover soil is less than 15% in the plot with 1m of cover soil directly overlying the tailings with no capillary break provided. While the authors acknowledge that these are very early and preliminary results, they do suggest that a capillary break is present in the GCB plot as well as in the plot with the conventional layered soil cover. Ongoing monitoring will evaluate the extent to which the capillary barrier effect may act to limit infiltration of water and diffusion of oxygen into the tailings.

6. SUMMARY

Field trials have been developed to evaluate a GCB. It has been found in previous studies that the GCB is effective when tested in laboratory column tests. The trials have been developed with side-by-side test plots on the tailings management facility of HBMS in Flin Flon, Manitoba. Instrumentation has been installed to measure in situ soil moisture, matrix suction, gas concentration, and climatic conditions.

Early data suggests that a capillary break has formed in the test plot containing the GCB covered by 1m of cover. More data analysis will be completed to evaluate the effectiveness of the GCB.

Monitoring of the test plots will continue, as well as data analysis and the installation of the gas concentration monitoring.

ACKNOWLEDGEMENTS

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REFERENCES


Park, K., (2005), Evaluation of a Geosynthetic Capillary Break, M.Sc. Thesis, Department of Civil and Geological Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada


Figure 2 Plot A Soil Moisture Readings

Figure 3 Plot B Soil Moisture Readings
Figure 4 Plot D Soil Moisture Readings