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Bituminous geomembrane in extremely cold conditions

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ABSTRACT: This paper discusses the technical properties of a bituminous geomembrane and the test results obtained from installing and welding one in a very harsh environment to construct water retention ponds at a diamond mind in the Northwest Territories of Canada. It also discusses the lessons learned and, more specifically, precautions to take before and during installation in winter at the 60th parallel. Lastly, it examines the problems posed by permafrost and the solutions developed in Canada.

1 INTRODUCTION

Installing bituminous geomembranes in Arctic conditions: Construction of three retention ponds at the Diavik Diamond Mine.

2 LOCATION

2.1 *Location of the project*

The Diavik Diamond Mine is located on a 20-sq-km island in Lac de Gras, 300 kilometres northeast of Yellowknife, Northwest Territories of Canada. The mine is an unincorporated joint venture between DDMI (60%) and Aber Diamond Limited Partnership (40%). Both companies are headquartered in Yellowknife. DDMI is a wholly owned subsidiary of Rio Tinto, which is headquartered in London, England, and Aber Diamond Corporation of Toronto, Ontario, which wholly owns Aber Diamond Limited Partnership. DDMI is the operator of the project.

2.2 *Schedule*

- Pond 14: completed in late April 2005;
- Pond 2: part one completed in June 2005 and part two in November 2005; and
- Pond 13: completed in December 2005.

2.3 *Weather conditions experienced during installation*

- From –25 °C (–13 °F) to –5 °C (+23 °F);
- Very windy; and
- Snow, one morning.

Table 1. Pond 14

Area	12,000 m^2 (129,167 ft^2)
Length of the crest	680 m (2,231 ft)
Slope	3.2 h: 1 v (initially)
Height	6 m (20 ft)

Table 2. Pond 2

Area	25,000 m^2 (269,098 ft^2)
Length of the crest	1,100 m (3,609 ft)
Slope	3.1 h: 1 v (initially)
Height	9 m (30 ft)

Table 3. Pond 13

Area	10,000 m^2 (107,639 ft^2)
Length of the crest	450 m (1,476 ft)
Slope	3 h: 1 v (initially)
Height	5 m (16 ft)

3 PROJECT

3.1 *Sediment control ponds*

The work involved building three dikes to create three retention ponds.

Only the slopes were waterproofed using a geomembrane. The permafrost was watertight enough to prevent water leakage at the bottom of the ponds. The ponds were designed as repositories for surface water runoff during mining operations as part of Diavik Diamond Mine's commitment to environmental protection. The mine site situated on an island within Lac De Gras, the water of Lac De Gras is of the pristine fresh water lakes in the world and therefore the Diavik has committed to the highest of environmental standards.

3.2 *Pond 14*

Pond 14 was intended to be a temporary structure. The dike was waterproofed using Coletanche IS1. In a few years, a larger pond will be constructed.

3.3 *Ponds 2 and 13*

Pond 2 and 13 are intended to be permanent structures. These two ponds are expected to remain functional for many years based on

- Past experience with dikes waterproofed with bituminous geomembranes over 30 years ago; and
- Research by the French Commissariat à l'Énergie Atomique (Atomic Energy Commission) and the U.S. Nuclear Regulatory Commission.

3.4 *Installation*

A local company (A&A Technical Services) based in Yellowknife, NT, specializes in geomembrane installation in cold weather conditions. They remarked that bituminous geomembranes retain their flexibility even when stored and unrolled at –40 °C (–40 °F). No special precautions such as inside tunnels were required during welding, which was performed in the open air at 025 °C (–13 °F).

3.5 *Tasks of representatives on-site*

3.5.1 *Consultant*

- Ensure that the main contractor complied with QC/QA requirements, especially for the quality of the support;
- Monitor QC/QA during the first few days until the operation was running smoothly: and
- Assess possible savings with regard to the coarse material available at the site (e.g., using a 150 mm minus material rather than a 50 mm minus material).

3.5.2 *Manufacturer/distributor supervisor*

The supervisor's presence was required by the manufacturer to train A&A Technical employees and ensure that the installation work was done properly.

3.6 *Impact of weather conditions and temperature*

The installation and welding of bituminous geomembranes is largely independent of temperature and weather conditions.

Despite the fact that it snowed, the installation of the geomembrane continued as usual. Geomembranes can thus be installed at any time of the year.

4 FOUNDATION PREPARATION

4.1 *Photos of natural ground conditions*

Photo 1. April 18, 2005.

Photo 2. April 18, 2005.

4.2 *Customer bedding material (for the initial HDPE solution)*

- The design specified a 50 mm minus geomembrane bedding and cover material. Tests carried out on site showed that a 150 mm minus material could be used for bedding and cover without damage to

the geomembrane. The 150 mm minus bedding material was compacted.
- Cover material was dumped along the toe and pushed approximately two-thirds up the slope. Cover material was then dumped along the crest and pushed down the slope over the geomembrane.
- The use of relatively coarse bedding, cover materials and cushion materials as well as the elimination of the need for a protective geotextile under and on top of the geomembrane (the bituminous geomembrane consists of a non woven polyester geotextile at the heart of the membrane. This geotextile is protected by the bitumen against any bio degradation leading to enhanced durability and long life) reduced the total cost of construction.

4.3 *Bituminous geomembrane optimisation results in savings for the customer*

- A coarser bedding material can be used: 0/50 is not required for bituminous geomembranes. 0/150 material is sufficient, especially with 5 mm thick geomembrane.

5 ANCHOR TRENCH EXCAVATION/ PREPARATION

- The geomembrane had to be completely anchored in a trench at the toe of the dike to assure the continuity of the watertightness.
- Because of the permafrost, the trench required blasting. To protect the geomembrane at the transition between the slope and the bottom of the trench, some material was put in the trench to smooth and round the support.

Photo 3. Bottom of trench.

5.1 *Slope*

- The slope was initially designed at 3H: 1V.
- Due to trafficability issues with the construction equipment that was available for placement of the liner supporting fill, the liner was placed on an average slope of 4H: 1V.
- Experience on other projects has shown that a slope angle of about 26° (approximately 2H: 1V) can be achieved.

5.2 *Bentonite modified soil*

A bentonite-modified soil was used in the trench, which was excavated approximately two metres into the permafrost:

- To provide increased protection for the geomembrane at the bottom of the toe trench; and
- To improve the watertightness at the junction of the permafrost and the geomembrane.

5.3 *Trench at the top of the slope*

A trench at the top of the slope was not necessary but would certainly have been a safer solution to avoid wrinkles before covering.

Instead of excavating a trench at the top of the slope, another option would use two pins (20 cm or 8 inches long) for each width of geomembrane.

6 LINER INSTALLATION

Photo 4. Liner installation.

6.1 *Installation crew*

6.1.1 *Number of people in the crew*

It takes the same amount of manpower to install a bituminous liner in harsh conditions as it does for an HDPE membrane if using a manual beam.

- A hydraulic beam was used for ponds 2 and 14 and only two workers were needed to unroll the geomembrane.
- Two welders were needed to weld the joints and one assistant to roll and seal after welding.
- One worker was needed to visually inspect the quality of the seam and finish the joint.

6.2 *Installation rate*

On average, approximately 2,00 m^2/day was installed in all kinds of weather.

Photo 5. Torching.

In some instances, the bituminous liner installation rate was limited by the production rate of the earthwork.

7 TORCHING

The installation could have been improved with more stringent preparation prior to the start of the installation work. This problem was minimized due to the contractor's experience in installing other types of geomembranes.

Photo 6. Testing.

8 QC/QC

There was very good compliance with QC/QA requirements despite the conditions.

There was a manual ultrasound device on site to check the quality of the seams.

There was a vacuum bell on site for testing particular points.

All seam testing and destructive test samples were documented daily and recorded in a computer-generated report.

One man was completely dedicated to this work.

9 CONCLUSION

Bituminous geomembranes can be:

- Used in very harsh environments;
- Used with crushed rocks of any particle size as covering material; and
- Installed in windy conditions due to its large unit mass.

Bituminous geomembranes are much more economical, especially when the cost of the support and cover material is taken into consideration.

Bituminous geomembranes have non-skid surfaces, making it safer for workers to walk on them.

The very low thermal expansion coefficient of bituminous geomembranes means they remain flat when installed (no wrinkles, no cracks).

Bituminous geomembranes can be installed using only a torch and a roller, while polymeric geomembranes require special equipment operated by specialized workers.

Since the manufacturer trains local people as welders:

- They are available when the customer needs them. This means greater flexibility and fewer delays.
- Extensions and repairs are easier because local people are trained to do the work even done by the client's maintenance workers.