January 30, 2014

REPORT ON

Foaming Resin Proof-of-Concept Test Report

Submitted to:

Public Works and Government Services Canada (PWGSC)
Telus North Tower
5th Floor, 10025 Jasper Avenue
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Attention: Brad Thompson

REPORT

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1.0 INTRODUCTION

At the request of Public Works and Government Services Canada (PWGSC) a proof-of-concept trial to assess the suitability of using a two-part foaming urea-silicate resin for remote void filling was carried out in a shipping container located in the South Pond tailings impoundment area, at the Giant Mine Remediation Project (GMRP) in Yellowknife, NWT, on October 24, 2013.

The tests were carried out to assess the mobility of the un-foamed resin product, and to develop a pour strategy which will allow for the effective filling of the underground voids. The effectiveness of storage and use of the foaming resin during winter months in a northern climate were also assessed.

2.0 PROOF-OF-CONCEPT TRIAL

2.1 Testing Procedure

Details regarding the proof-of-concept trial were presented in our technical memorandum entitled "WORK PLAN #:006 FOAMING RESIN EXECUTION PLAN" dated October, 23rd, 2013. For completeness, a copy of that TM is included in Appendix A.

Normet Canada Ltd. (Normet) were contracted by Clark Builders to perform the foaming resin proof-of-concept test. An approximately 12.2 m long, 2.5 m wide, 2.5 m high shipping container was provided by Clark Builders to Normet for the purposes of simulating an underground drift on surface. This shipping container was placed on the South Pond tailings impoundment area for the test.

2.2 Materials Used for Test

Prior to the test, calculations were made to estimate the volumes of resin required to construct at least two test plugs within the shipping container during the surface trial. Normet transported three 55 gallon drums of Tampur 117 Part A and three 55 gallon drums of Tampur Part B to site, along with a small positive displacement pneumatic pump and associated hydraulic lines. The equipment was assembled and tested on the day prior to the test and was found to be functioning correctly.

2.3 Pour Strategy

A number of holes were cut into the top of the shipping container to simulate a drill hole intersecting an underground opening. An approximately 15 mm diameter delivery hose was attached to the inline static mixer and inserted into the shipping container through a delivery hole. The flow of resin was controlled from outside the container by a Normet representative.

2.4 Work Carried Out

The test pour commenced at ~14:30 and finished at ~17:30.

The plug constructed in the shipping container was the full width of the container, ~3 m long, and ~1.8 m high with a cone of resin on top extending up to the delivery point (Figure 1). The progress of the foam plug development was monitored using a fixed camera. A shortened montage of this footage has been produced and will be forwarded under separate cover to PWGSC.

During the trial, the resin was poured onto the flat floor of a shipping container. The resin did not migrate more than 50 cm from the delivery point before foaming occurred.

The plug was not entirely completed due to inclement weather conditions and fading daylight, the use of a small diameter delivery line limiting the volume of resin which could be delivered.

Post-curing, a notch was excavated in the face of the plug with a hand axe to obtain samples of the foamed resin. The surface of the plug, which was in contact with air, appeared to be weak and fissile. However, where the foamed product was not in immediate contact with air (i.e., in the face of the excavated notch), it was found to be more coherent and had a closed cellular form.

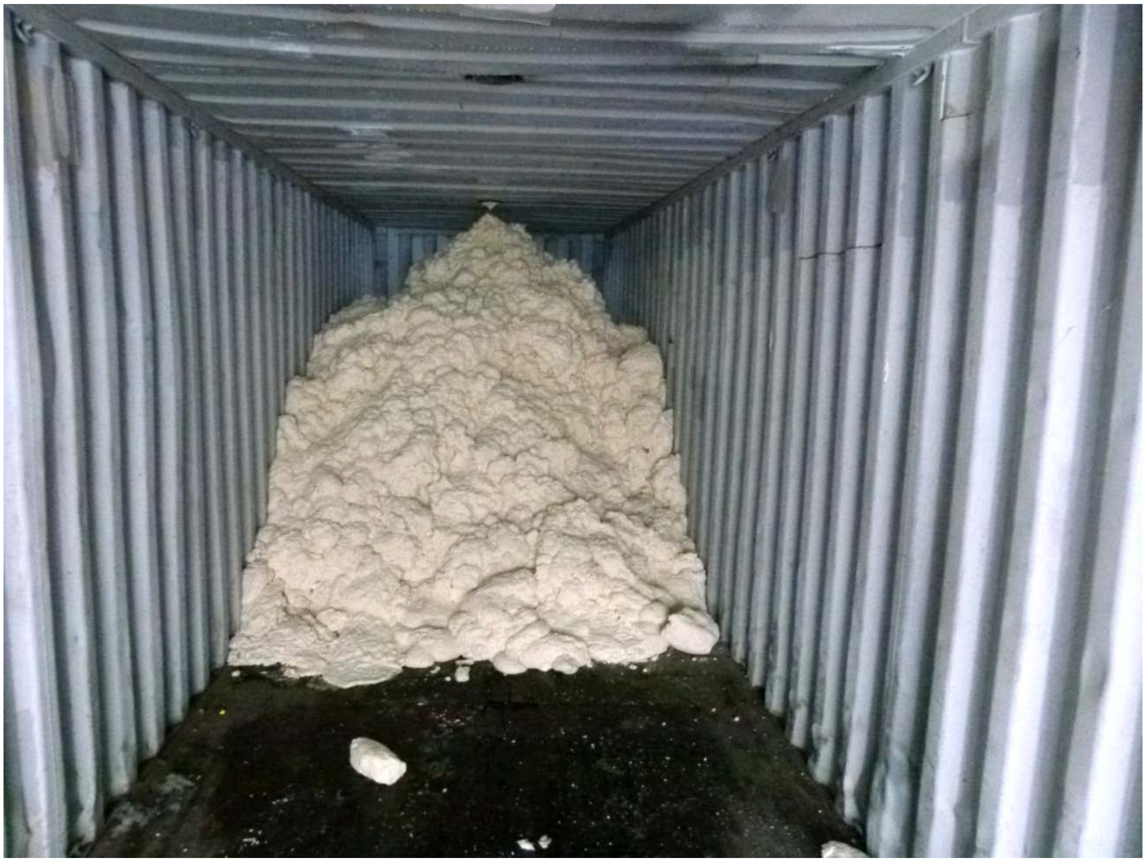

Figure 1: Foamed Resin Plug

3.0 DISCUSSION

3.1 Incomplete Trial

As discussed above, the plug was not completed due to inclement weather conditions and fading daylight.

The suction hoses which extracted the product from the drums frequently recoiled out of the drums which resulted in interruption to resin delivery. The delivery hose which fed the resin into the shipping container was of a smaller diameter than would typically be used. The combination of the two resulted, in our experience, in slower than normal resin delivery for plug construction. Nevertheless, it is expected that even with these problems, with additional time, the plug pour would have been completed and the full width/height of the shipping container completely sealed.

The mobility of the un-foamed resin was satisfactory. However, the small diameter of the delivery line may also have limited the mobility of the un-foamed resin. On a production scale, a larger diameter hose would be used for product delivery. However, because of its unit weight, the un-foamed resin may spread further prior to the initiation of foaming. Additionally, the potential distance of migration along an inclined surface prior to the initiation of foaming was not tested as a trial was not undertaken on an inclined surface.

The use of a larger diameter delivery hose and the potential distance of migration on both a flat and inclined surface should still be tested.

The proof-of-concept trial was also planned to be undertaken within/onto a sample of underground run-of-mine muck. The aim of this trial was to determine whether the permeability of the muckpile would be sufficient to allow the resin to “soak into” (or saturate) the muck. As the location of the trial was moved from its originally proposed location on the morning of the test, this portion of the proof-of-concept trial could not be completed. It is our opinion that whether or not the saturation of the muck with resin prior to the initiation of foaming is possible should still be tested.

3.2 Foam Strength

While no specific strength threshold has been established for the foamed resin plug, from visual inspection and crude field strength tests, it is expected that the foamed plug will be capable of withstanding the modest loads imposed by a small head of paste.

3.3 Other Issues

Several other issues were highlighted during the test which will require resolution before this technique can be used for the construction of underground barricades.

3.3.1 Fumes generated during the reaction

As part of the chemical reaction between Tampur Part A and Part B, a significant volume of chemical fumes were generated. These fumes filled the shipping container and their composition was unknown to Normet. While the fumes were being generated personnel involved in the test moved to a safe distance away from the shipping container to avoid exposure. A wind sock was also installed adjacent to the shipping container to monitor the wind direction.

The composition of these fumes and the hazards associated with their generation, particularly in a confined space such as an underground excavation must be clearly identified. Normet have been requested to provide this information to all concerned parties.

3.3.2 Temperature of resin during storage and use

It is the manufacturer's recommendation that the Tampur 117 components be stored and used above 18°C, or a reduction in the expansion factor can occur. The weather on the day of the test was below freezing with snow falling for most of the day. No suitable location for the storage of the resin components during the test was available and as a result, they remained outside for the duration of the test. It is expected that the low ambient temperature caused the resin components to cool throughout the day. It is likely that this cooling of the resin reduced its expansion factor causing more resin to be required to building the same volume plug.

A method of maintaining constant temperature in the resin components during full scale production use of this foaming resin should be designed for the winter months. This method should encompass both storage of and use of the resin.

3.4 Recommendations

As an initial trial of the usefulness of a foaming resin for remote underground backfill barricade construction, the proof-of-concept trial was successful. However a number of issues were highlighted which will need to be addressed prior to its use underground.

Due to the limited time frame for the proof-of-concept trial the tests of the resin's mobility on an inclined surface and the interaction of the resin with underground mine muck were not completed. It is expected that both of these scenarios will occur if the resin is used underground and so these tests should be undertaken in the future.

The pumping equipment used for the trial restricted the pour rate due to the small diameter of the hoses and the size of the pump used. On a production scale the equipment used should be of a higher flow rate capacity and should be tested for compatibility with the pour methodology.

During the proof-of-concept trial significant fumes were produced during the reaction of the resin. The exact composition of these fumes is unknown by Normet. Normet have been requested to provide a lab report on the chemical composition of these fumes.

The ambient air temperature is of concern for the production scale use of the foaming resin as it can prevent the resin from reacting properly. It is recommended that a method of storage be developed which keeps the component parts of the resin at or above 18°C both prior to and during use.

4.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or requirements, please contact the undersigned.

GOLDER ASSOCIATES LTD.

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APPENDIX A

1314260010-049-WP-Rev0-1000 Resin Test Plan

October 23, 2013 Reference No. 1314260010-049-WP-Rev0-1000

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WORK PLAN #: 006
FOAMING RESINS EXECUTION PLAN

Dear Mr. Thompson,

1.0 INTRODUCTION

A proof-of-concept trial for remote void filling at the Giant Mine Remediation Project (GMRP) in Yellowknife, Northwest Territories (NWT) will be undertaken commencing in the final week of October, 2013

The trial will be undertaken to assess the suitability of using a two-part foaming urea-silicate resin for void filling at the Giant Mine. Tests will be carried out in a number of shipping containers located in the tailings impoundment area to assess the mobility of the un-foamed resin product and determine a pour strategy which allows for the effective filling of the underground voids. The effectiveness of storage and use of the foaming resin in a northern climate in winter will also be assessed.

2.0 SCOPE OF WORK

Representatives from Normet Canada Ltd. (Normet) and Golder will be present on site during the proof-of-concept trials at the tailings impoundment area. The tests will be conducted by experienced Normet staff on behalf of Clark Builders.

2.1 Testing methodology

A series of tests will be carried out during the proof-of-concept trial to assess the suitability of the foaming resin in a number of scenarios including those discussed below.

2.1.1 Filling a shipping container

The desired outcome of the proof of concept testing is to construct a foamed resin plug inside a shipping container at the tailings impoundment area. This test is designed to simulate the construction of a plug in an underground opening of similar dimensions. The surface trial will allow the plug construction to be monitored constantly. This should allow in the design of an effective resin pouring strategy.

2.1.2 Mobility and flow control of un-foamed resin

It is understood that the viscosity of the mixed, un-foamed resin varies with temperature. Once poured into a void underground, the rate at which the un-foamed resin will flow away from the distribution point prior to foaming, because of the anticipated difference in product delivery temperatures (affected by such things as on-site storage conditions, ambient temperature, batching equipment and delivery pipe temperatures, etc.), is at present, unknown. Therefore, to control of the size and location of the foam plug being constructed, a number of pouring methodology trials will be carried out to develop an acceptable technique for foam delivery.

2.1.3 Pouring into existing muckpiles

The effect of pouring resin into underground muckpiles and previously backfilled areas is unknown. A test will be undertaken where mixed resin will be poured onto a mine waste muckpile adjacent to the shipping containers. While somewhat unknown, it is expected that the liquid resin will soak into the muckpile and cause the muckpile itself to expand and fill the void.

2.2 Health and safety

Golder personnel working in the area of the foaming resin test will be subject to a site specific Health and Safety plan that includes specific hazards associated with working with this material.

While the final foamed resin is chemically inert, the component parts do pose health risks. As a result, only those Golder personnel directly involved in the test will be permitted to participate. An eye wash station and appropriate PPE will be provided during the test.

The test will be undertaken on the tailings impoundment area and the existing site specific Health and Safety plan used for the Paste backfill test will be used for this work.

3.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or requirements, please contact the undersigned.

GOLDER ASSOCIATES LTD.

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