Smart Foam Liquid Concentrate Solutions Series

WHITE PAPER

Revolutionizing Surface Tailings Disposal and Backfilling

ABSTRACT

This white paper introduces mine owners, mining and geological engineers, mine facility and primary production managers, permit-granting agency staff, heavy equipment operators, and other regulators and construction professionals to a new, more sustainable, and more economical practice for improving surface tailings disposal and backfilling: Smart foam liquid concentrate (SFLC) as the transport medium.

SFLC technology involves the introduction of engineered air bubbles to replace water as the main transport medium, resulting in an environmentally safe and less expensive alternative for surface tailings disposal and backfilling.

KEYWORDS

Mine tailings; tailings; slimes; tailings pile; tails; slickens; surface tailings disposal; tailings transportation; transport medium; water conservation; smart foam liquid concentrate (SFLC); engineered air bubbles; flow velocity; plug flow pattern; abandoned mines; impoundment ponds; beach angle; and Cellular Concrete Solutions.

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BACKGROUND

The mining industry excels at leveraging technology to effectively extract minerals from mine ore, but the process is not 100% efficient. As environmental concerns and regulations advance, mine tailings – ground rock and process effluents generated from mine processing operations – and tailings management are becoming a growing concern.

HISTORIC TAILINGS MANAGEMENT

Historically, mine tailings (also referenced as tailings, slimes, tailing piles; tails, and slickens) were discharged directly into the nearest surface watercourse. The practice is seldom used today, as it has the potential for creating social and environmental burdens (and associated costs for restitution and remediation) far outpacing the value of the extracted minerals.

The historic practice contributes still today to the negative perception the public holds of the mining industry, fostering, along with noise, dust, and aesthetic issues, "not in my backyard" (NIMBY) mining attitudes worldwide.

The mining industry has undertaken tailings storage management since the early 1900s, with benchmark mine waste management regulations enforced beginning around 1930. Surface containment, in-pit, co-disposal, and off-shore tailings storage methods have proven effective.

Though a trend toward processing minerals, detoxifying the resulting tailings, and placing them into the environment without using a tailing management facility may be developing, conventional impoundment storage – a surface retaining structure designed to store both tailings and mine water – remains the most common method of mine waste management.

Tailings are often stored below ground in previous worked out voids. The tailings are generally mixed with a binder, usually cement, and then pumped underground to fill voids and provide support of the underground mine. Water is typically the transport medium for below-ground-tailings storage.

A NEW, MORE SUSTAINABLE PRACTICE FOR IMPROVING SURFACE TAILINGS DISPOSAL AND BACKFILLING IS NOW AVAILABLE

Leveraging smart foam liquid concentrate (SFLC) technology could revolutionize surface tailings disposal and backfilling by providing a new, environmentally safe, and less expensive alternative to traditional methods.

Traditional tailings transportation uses water (hydraulic placement) as the transport medium. SFLC technology instead involves the

introduction of engineered air bubbles, which replace the water as the main transport agent.

Technical and environmental advantages for using SFLC technology-engineered air bubbles as a transportation medium include:

- Air bubbles minimize water use in tailing transportation. Water transport of one cubic yard [0.765 cubic meters] of tailings uses about 101 gallons [382.4 liters] (50% tailings and 50% water). Air bubble transport of one cubic yard [0.765 cubic meters] of tailings uses about 4 gallons [15.15 liters] of water (50% tailings and 50% air bubbles).
- Air bubbles require less energy to pump than water.
- Air bubbles suspend the tailing particles during transportation without segregation, eliminating the need for velocity, reducing energy demands, and allowing for a wider range of pumps to be used.
- Air bubbles cause less abrasion on the pipeline because of the lower flow velocity and plug flow pattern.
- Air bubbles utilize less energy than water because air weighs less than water.
- Air bubbles suspend without segregation tailing particles during transportation, eliminating the need for high-pumping velocity, further reducing energy demand, and allowing for a wider range of pumps that can be used for tailings transport.
- Air bubbles are generated on site, eliminating the need to pump in or haul a water source.
- Air bubbles are 100% biodegradable.
- Air bubbles can be designed to collapse under a vertical height. When used with a paste backfill, this allows the maximum amount of tailings to be placed in the mine, while also reducing pressure requirements.
- Air bubbles allow more solids per unit area to be pumped than water – 50% solids with engineered air bubbles weighs 53 pounds [24.05 kilograms] … 50% solids with water weighs 81 pounds [36.75 kilograms].
- Air bubbles may eliminate the need for an impoundment pond. However, if necessary, when placed in an impoundment area there would be no excess water with SFLC technology.
- Air bubbles permit particle sizes as large as 0.75 inches [1.905 centimeters]
- Air bubbles, when used in small amounts (3% to 8%) with conventional transportation methods or with paste backfill, also reduce transport energy demand while allowing for a wide range of pump types.

Water Reduction– *SFLC technology is ideal for backfills having no or limited access to water.*

4 GALLONS

amount of water needed for air bubble transport of one cubic yard of tailings.

101 GALLONS

amount of water needed for water transport of one cubic yard of tailings.

- Air bubbles can produce, after disposition, almost any desired final beach angle on the dry stack.
- Air bubbles permit tailings to be gravity-fed into abandoned mines.

There are also significant cost advantages for using SFLC technology-engineered air bubbles for tailings transportation. Air bubbles reduce the cost of transporting higher-density tailings product while providing a major reduction in water and energy expenses. In instances where impoundment ponds can be eliminated, costs associated with impoundment pond construction and maintenance (and community environmental concerns) are also eliminated.

CASE STUDY: SFLC TECHNOLOGY SUPPORTS KANSAS MINE BACKFILL PROJECT

An active landfill in Kansas City, Kansas was sited on top of an abandoned limestone mine. To prevent any collapse, which could result in ground settlement, possible breach of the landfill liner, and potential allowance of contaminates to enter the groundwater, the old mine was required to be filled. The mine void height varied from five to twenty-five feet [1.525 to 7.62 meters] with a volume of approximately 150,000 cubic yards [114,685 cubic meters], affecting twenty to thirty surface acres.

Due to the amount of water within the mine, (approximately twenty five percent [25%] of the volume) using conventional fly ash slurry or a cemented-sand mixture as fill material would have been very difficult. This option would also have been a very expensive alternative, and would produce an unreasonably long construction schedule.

The surrounding Kansas City area has numerous limestone aggregate quarries with an abundance of excess crusher fines available for use as an inexpensive backfill material. However, the active landfill was isolated from any significant water supplies for use in transporting and placing these crusher fines, making hydraulic placement methods using crusher fines an unsound option.

To employ the crusher fines, a cost-effective placement process was necessary. SFLC technology provided the cost-effective placement solution.

Injection holes were drilled into the mine from the surface at approximately 200-foot centers. These holes were nine inches in

FIGURE 1

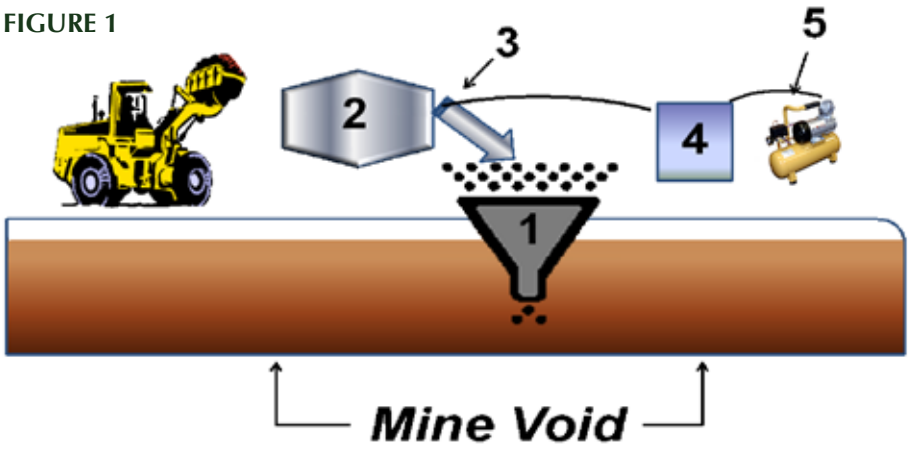

FIGURE 1. At time of placement, a one cubic yard metal hopper (#1) with a bottom discharge port is placed at the top of an injection hole. A volumetric cement mixer, modified to hold a predetermined amount of material, is used to mix the smart foam liquid concentrate into the tailings (#2). Tailings are dumped into the metal volumetric hopper using a rubber-tire loader. Smart foam is injected in the volumetric mixing auger (#3) and the foamed tailings are discharged into the hopper, then gravity fed into the mine at a predetermined rate (cubic yards per hour). The smart foam is generated using a mechanical foam unit (#4) powered by an air compressor (#5).

diameter, with a depth of 250-300 feet. A one cubic yard metal hopper with a bottom discharge port was placed at the top of these injection holes at the time of placement.

The SFLC technology backfill placement process used for the case study project is diagramed in FIGURE 1 (above).

SFLC-technology-enabled air bubbles were engineered to sustain a working life of seven days, so material placed in previous days continued to have lateral movement. This smart-foam engineering maximized the amount of area filled from one injection hole, reducing the number of drill holes required for adequate backfilling.

During the scope of the project, tailings placement was monitored with remote cameras to determine lateral movement of the fill material. Distances exceeding 300 feet were verified.

When the project was completed, holes were drilled into the in-place material to determine the bearing capacity and the percentage of the mine that was full. The bearing capacity of the in-place material exceeded 140,000 pounds per cubic foot [2,242,585 kilograms per cubic meter]. The mine was determined to be more than 95% filled, exceeding project requirements of 85%.

The SFLC technology placement solution was so efficient, mechanical pumps were not required, which resulted in significantly less equipment and manpower required versus conventional placement methods and cost savings of one-third compared with traditional methods.

Without SFLC technology, the landfill would have been forced to close down prematurely.

MEARL TRANSPORT™

Mearl Transport enables SFLC technology-engineered, air-bubble solutions for surface tailings transportation, disposal, and backfilling challenges.

CONCLUSION

Smart foam liquid concentrate technology revolutionizes tailings disposal and backfilling, providing a sustainable, less expensive, and safer alternative to traditional, water-transport-medium-based, backfill methods. The introduction of air bubbles as the main transport agent yields many benefits, supporting the economic, environmental, and social goals of mine stakeholders.

NEXT STEPS

More information about SFLC is available by contacting Rich Palladino, President, Cellular Concrete Solutions:

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ABOUT CELLULAR CONCRETE SOLUTIONS

Cellular Concrete Solutions engineers integrated, smart foam liquid concentrate solutions for construction, mining, and manufacturing applications, applying research, innovation, and technical expertise and support to help specifiers, contractors, and manufacturers expand markets, improve quality and job site safety, and reduce project/ environmental costs.

The innovative Cellular Concrete Solutions product line includes protein, synthetic, and protein/synthetic blend liquid foam concentrate formulations for use in insulated concrete roof deck and floor construction, low slump and lightweight concrete applications, and mining and geotechnical applications, including pervious cellular lightweight concretes.

The engineered foams are designed to release their unique physical properties only when mixed with the cementitious materials and a chemical reaction occurs. Construction professionals find Cellular Concrete Solutions' smart foaming agents to be the most stable pre-formed products in the cellular concrete industry, durable cell structures not affected by long pump runs, extended mixing, or most fly ashes or ground granulated blast-furnace slags.

Pre-formed smart foaming agent products include:

- Mearl 40™ - for low-density, insulated concrete roof deck and floor applications
- Mearl Geofoam 40 Non Pervious™ - for low-density geotechnical construction applications
- Mearlcell 3532-40™ - for pre-cast construction applications
- Mearl Transport™ - for surface tailings disposal and backfilling
- Mearl Geofoam Non Pervious™ - for geotechnical, grouting and tremie applications
- Mearl Geofoam Pervious™ - for pervious geotechnical applications
- CellFlow™ - for the production of CLSM materials (flowable fill)

Cellular Concrete Solutions also sells foam generation systems designed specifically for producing consistent foam for cellular concrete production, including jobsite-tough tank generators, tankless auto generators, and portable lab-foam generators for producing accurate results in the laboratory.

More information about the company and its cellular concrete solutions is available online at www.cellular-concrete.com.