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Elko Roundtable 2013:

Material co-disposal and co-placement

by Bryan Ulrich

Knight Piésold's annual roundtable discussion was held at the Red Lion Hotel and Casino in Elko, NV on March 14. This year the title was, "Roundtable discussion on material co-disposal/co-placement in the mining industry."

This topic was chosen because of the benefits that the mining industry could realize through the advancement of improved methods of storing tailings and mine waste and from reducing short- and long-term environmental hazards while reducing the footprint of these facilities and making strides toward attaining a walk-away solution.

La Quinua combined heap leach facility (HLF) and tailings storage facility (TSF) was discussed at the 2013 Elko Roundtable in Elko, NV.

Knight Piésold had a local representative, Bryan Ulrich, as well as representatives from its Denver, CO office, including Tom Kerr, president of Knight Piésold's U.S. practice, and Jeff Coffin, Ph.D., geotechnical engineer, to help facilitate the discussion. The event played host to about two dozen attendees from several western states. Attendees included personnel from more than 10 mining properties, various corporate offices and academia.

The purpose of the roundtable was to exchange ideas and information pertaining to broad topics revolving around the subject of co-disposal/co-placement in the mining industry. Compared with traditional conferences and symposia, the roundtable forum tends to provide a less inhibited format for discussion. In the roundtable format, lively discussions and applicable tangential departures are encouraged.

Bryan Ulrich, member SME, is senior vice president, Nevada Operation Knight Piésold, email bulrich@knightpiesold.com.

This was the seventh in the series of the Elko Roundtable events. Previous roundtables pertained to:

- Heap leach pad design, construction and operation.
- Design, construction and operation of tailings storage facilities.
- Site-wide water considerations.
- Mine closure and cover design.
- Strides toward sustainability in mining.
- High-density tailings, paste and filtered tailings.
- Acid rock drainage for engineers and environmental scientists.

The roundtable created a good environment to discuss the current practices, challenges and accomplishments associated with co-disposal/co-placement of materials in the mining industry. Since there is considerable overlap between the roundtable's subtopics, the conversations frequently wandered from topic to topic and back again. In keeping with the spirit of an open roundtable discussion with unbridled conversation, we have chosen to create "sanitized minutes" of the meeting, wherein specific quotes are not attributed to their author. Rather, the proceedings of the discussions are presented in a stripped down version in order to avoid stifling the free exchange of ideas. The following is partly a tangential discussion and partly the proceedings of the roundtable.

The day began with safety share. This year's safety share topic was back safety and back injury prevention. Preventing back injuries is a major workplace safety challenge. According to the Bureau of Labor Statistics, more than one million workers (not limited to miners) suffer back injuries each year. And back injuries account for one of every five workplace injuries or illnesses. One-fourth of all worker compensation claims involve back injuries, costing industry billions of dollars on top of the pain and suffering of the employees. These injuries can occur when an employee is lifting or carrying a load, but other causes have also taken place.

Following the safety share, the conversation began with introductions and a round robin answering of the question, "What does today's discussion topic raise in your minds?" The responses to that question were many and varied, including:

- Combined facilities, such as a combined heap leach and tailings facility, where a heap leach facility is constructed to perform as the embankments for tailings storage.
- Using milled tailings in some form as a closure cover for waste rock.
- Combining tailings and waste rock to reduce/preclude the production of acid rock drainage (ARD).
- Placing waste rock and filtered tailings together to reduce/preclude ARD. [1]
- Agglomerating tailings onto heap leach ore, helping heap performance and avoiding the need for a tailings facility.
- Constructing a filtered tailings facility upon a completed heap leach pad.

It was mentioned that the capital and operating cost to produce filtered tailings is becoming more economical at higher production rates. In addition, filtered tailings facilities in general may often be viewed as a preferable alternative to conventional tailings facilities due to their water-saving characteristic and the possible avoidance of large embankments.

One participant discussed a project that includes filtering tailings at a high production rate. At this project, the current design includes an under drain system, but no lining system of any kind. It is beneficial that their tailings are essentially benign. There was some discussion pertaining to the occurrence of a phreatic surface within such a facility. The representative from that mine indicated that the design would result in a facility where the moisture in the tailings would consist of only capillary moisture; thus, no water would be expected to drain from the facility.

Following the round robin, the author gave a presentation on co-disposal of materials in the mining industry. Co-disposal combines waste streams in a variety of ways. Similar to the thickened tailings continuum (ranging from conventional tailings slurry to filter cake), mixing of mine waste streams has a continuum that ranges from unmixed to homogeneous:

1. Separate disposal.
2. Waste rock and tailings are disposed of in the same facility, but without extensive effort to mix the waste streams.
3. Waste rock is added to a tailings impoundment or vice-versa.
4. Layered co-disposal: Horizontal layers of waste rock and tailings are alternated.
5. Conveyed co-disposal: Tailings and waste rock are trucked, conveyed or pumped to a facility separately and encouraged to blend at least partially at the deposition point.
6. Homogeneous mixtures: Tailings and waste rock are blended to form a fully homogeneous mixture.

Figure 1

Mixing two dissimilar granular materials (concrete sand and pea gravel) at the Paterson & Cooke facility in Golden, CO.

To date, there has been some success in designing and operating co-disposal sites. An example would be the South African practice of alternatively placing layers of dry coarse coal waste and slurried coal waste as a means of limiting the possibility of the occurrence of spontaneous combustion of coal waste.

An elusive goal, but one that has been written about numerous times, is the essentially perfectly blended mixture of tailings and waste rock. Such a mixture would have the following traits:

- Tailings and mine waste are mixed relatively homogeneously.
- Tailings essentially fill all of the voids between waste rock particles.
- Waste rock has predominantly rock-to-rock contact.

Ideally, thickened tailings and waste rock would

1. The author prefers the more descriptive term "filtered tailings" to the more commonly used term "dry stack," since filtered tailings are typically produced with a significant percentage of moisture, often very close to their optimal moisture content (and, therefore, nearly saturated if compacted) with respect to compaction.

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Figure 2

Preparing to mix pea gravel and tailings slurry using a relatively continuous feed apparatus at the Paterson & Cooke Facility in Golden, CO.

be mixed and compacted (if necessary) to result in a mixture that is essentially saturated, but without any free water (i.e., it would exist in a condition near the zero air void curve on a compaction test report). Benefits/goals of achieving the essentially perfectly blended mixture of tailings and waste rock include:

- Reduced facility footprint area.
- Waste mass exhibits a shear strength similar to waste rock.
- Waste mass has a low permeability akin to tailings.
- The combined waste exhibits a low oxygen diffusion rate.
- The waste mass may be able to greatly reduce ARD production.
- Because the waste mass should be stable throughout its operating life, improved closure opportunities should exist.

Due to their high shear strength and low permeability, a successful co-disposed tailings and waste rock facility would have several admirable traits. This would include a low oxygen diffusion rate that may preclude the production of ARD.

There have been numerous articles written about this application, the practice of co-disposing tailings and waste rock in an essentially perfect blend, where the tailings just fill the waste rock voids and the waste rock has good particle-to-particle contact. However, this has been an elusive goal at anything that approaches a full-scale operating mine level. One roundtable participant posed the question: "Fundamentally, co-disposal has several unique and potentially beneficial properties and, yet, in the past decade, there has been essentially no use of this technology. Why hasn't it succeeded, and will it ever be used in any large-scale operations?"

Why hasn't co-disposal made the jump to become a widely practiced technique? One limiting factor in developing a full-scale operation has been related to the lack of an appropriate mixing apparatus to reasonably combine tailings and mine waste at a large scale. There are recent developments that may help shorten the gap.

For a recently completed project, Knight Piésold developed a design for a co-disposed waste rock and thickened tailings facility. The goals were to design a facility with the following physical attributes:

- Accommodate waste rock and tailings at an approximate ratio of four parts waste rock to one part tailings (reflecting the approximate ratio of air void space typically found in waste rock piles).
- Result in an essentially homogeneous mixture using thickened tailings and with waste rock particles up to 0.3 m (1 ft) in diameter.

At the commencement of the work, various industry suppliers were contacted to assess whether existing equipment may be suitable for mixing tailings and waste rock at the target percentages, size fractions, solids contents and production rates. Products considered included equipment such as agglomerators, flow-through ball mills and continuous concrete mixers. It was found that none of the existing equipment would meet the goals of the project. Thus arose the need to develop a project-specific mixing apparatus (Figs. 1 and 2).

Due in part to the absence of adequate equipment to achieve the project's mixing goals, a bench-scale laboratory static mixing device was developed and tested. Testing results thus far have been favorable. The device has been used to satisfactorily demonstrate mixing of two dissimilar granular materials (concrete sand and pea gravel), and a granular material (pea gravel) and tailings slurry. In this test series, the slurry tailings had relatively low solids content, but that would not be the intention of a full-scale operation. Knight Piésold anticipates that upcoming projects will further the understanding and operation of the static mixing device, including the use of tailings at various solids contents.

A discussion followed the presentation of co-disposal. One topic related to injecting tailings into existing waste rock facilities. This application was investigated by a number of the attendees. However, this practice was largely dismissed by the participants due to the limited amount of tailings that would penetrate into the waste rock mass.

The discussion was followed by presentations by Tom Kerr and Jeff Coffin on the La Quinua combined heap leach facility (HLF) and tailings storage facility (TSF).

The Yanacocha Mine's La Quinua mill has a thickened tailings storage facility that is contained within an active heap leach facility. It is a unique and unprecedented design that provides its operator with cost, land-use and closure efficiencies. This design requires that leach ore embankments retaining the tailings provide the same level of stability required of major tailings dams. Compared to conventional tailings dam construction, the leach ore in these embankments is consistent with normal heap leaching operations; that is, with thick uncompacted lifts to maintain adequate permeability for leaching. The resulting loose structure makes the proper assessment of static and dynamic liquefaction a critical issue. The key design principle for avoiding liquefaction is to maintain the phreatic surface well away from the outer faces of the embankments and within large unsaturated structural shells. The facility was successfully commissioned in early 2008 and its performance to date has met or exceeded its design objectives.

Recently completed field investigations to assess pore pressure buildup within the facility have indicated that the facility is performing as designed.

In some aspects, this facility bears a resemblance to Barrick Gold Corp.'s pipeline tailings facility at the Cortez Mine in Nevada, which also couples a tailings facility and a heap-leach facility. At Cortez, the containment structures are composed of spent heap leach material, but these materials are placed in controlled, compacted engineered lifts to achieve stability requirements. At La Quinua, the containment structures are loosely placed and function as an active part of the heap leaching operation.

Attendees from Allied Nevada Gold Corp. (Allied) were in attendance of the 2011 Roundtable discussion (high-density, paste and filtered tailings) when Tom Kerr gave a similar presentation. That association eventually resulted in the development of a design for Allied's Hycroft Mine in Nevada. Kerr presented some information on the progress of that project (which is in the permitting process as of the date of this writing). The Hycroft combined HLF/TSF has many similarities with the La Quinua facility. The Hycroft facility is considerably larger than its predecessor at La Quinua.

Following a discussion of these facilities, professor Thom Seal, from the University of Nevada, Reno, presented a discussion on materials properties as they relate to co-disposal of mine waste. Seal's presentation included information pertaining to phase relationships, void ratios, permeability, unit weight of materials, the effects of capillarity and the characteristics of solution flow.

At the conclusion of Seal's presentation, there was considerable discussion about the practice of placing cement-amended tailings into mined-out underground workings. Cement-amended paste backfill has been used at mines around the world for many years, but such an operation is fairly novel in Nevada. This is largely due to the wording in Nevada's regulations for tailings storage. Nevada's regulations for tailings storage are heavily swayed toward placement of tailings on a clay or geosynthetic liner, an installation that would be impossible (or at least unlikely) in an underground opening. The mine operator who successfully permitted the use of cemented backfill in its mine in Nevada did so by demonstrating to the satisfaction of the state that there would be no potential contaminants migrating from the paste tailings.

One participant of the roundtable indicated to the group that, when a new technology or a technology that is new to the state or area, is introduced, the presenter should be well-equipped with information and study results in order to satisfactorily demonstrate how the technology protects the environment. The advancement of new technologies sometimes necessitates the obligation of educating regulatory authorities about the technologies.

After some additional discussion, the day ended as it had started — with a round robin discussion. With credit given to Joe Scarborough (former Republican congressman from Florida) and his Morning Joe program on MSNBC, the question was posed to the roundtable's attendees, "What, if anything, did we learn today?" The following are a few of those responses.

- There was interest in the static mixing device, including its possible use for mixing materials used for underground backfill.
- Participants were interested in the design of filtered tailings facilities that included no liner, and particular interest was focused on the seepage modeling needed for such a facility.
- Attendees were glad to learn that co-disposal is still being considered, that it is coming closer to a reality and that there seems to be some real potential for this application for the right projects.
- It was looked on admirably that difficult designs can be permitted. ■