TECHNICAL MEMORANDUM

TAILING DAM FAILURE RISK

Conventional earthen tailing dams and revetments at and within active mine sites create risk from potential, minor, and catastrophic failure. Such failure risk transfers to downgradient communities, mine employees, contractors, design firms, mining companies, investors, and surety/insurance stakeholders. YB Technologies, LLC provides a technology to reduce that risk by increasing tailing dam related Safety Factors above those common to dams constructed from available mine site materials, as well as above those dams constructed and maintained with traditional physical strength-enhancing materials.

Specifically, the MBT™ technology resolves acidic conditions and latent acid-generating properties of mining ore-based material residuals when used in preparing such materials for tailing dam construction. Acidic conditions whether immediate from direct exposure contact, or from acidity generated over time from natural degradation of sulfidic/pyrrhotic mineral residuals cause material particle dissolution (thus mass and strength loss) within tailing dam construction materials during and after dam construction, and while such at-risk structures are in operation at active mine sites or within abandoned mine workings.

MBT amendment addresses dam material softening from wet tailings-sourced acid mine drainage (AMD), as well as cementitious property loss from pozzolanic-hydroxide strengthening system exhaustion due to acidic neutralization. Importantly, MBT also concomitantly converts acid soluble heavy metals to non-leachable acid-stable mineral forms. While it is well known that tailing dams at inactive mine site are less apt to fail, active mines, by the nature of their functionality within dynamic and productive extraction operations, and legacy mines with high levels of AMD production, are repeatedly exposed to deviatoric stresses, strains, and varying disruptive acidic conditions. Common tailing dam design criteria based on long-term strength, construction methods, and maintenance plans prudently consider topography, geology, availability, and type of construction materials (borrow, tailings, waste rock, etc.), and the intensity and duration of mineral extraction opportunity to provide adequate and appropriate dam strength. Tailing dam design professionals rely on established well-proven practices to evaluate and enhance engineered properties of dam materials to increase tailing dam strength for sustainable longevity through numerous force and stress induced events.

These practices evaluate interactional forces and impactful stresses, and derived means to overcome adverse stressors given the material's geotechnical properties and engineered strength characteristics. Gravity, the flow of water, particle properties, particle-to-particle interaction, lateral and shear stress, pore pressure, hydraulic conductivity, and cyclic stress among many other physical strength and geotechnical factors are addressed to overcome potential failure while mitigating cost.

Acidity (and/or the potential for material to generate acid) is a chemical reaction failure factor that may not receive critical or adequate consideration in tailing dam design for long-term impact. Tailing dam construction materials that contain latent sulfidic/pyrrohtic residuals and other acid-generating matter are prone to strength loss when acidity slowly mineralizes constituents of these materials to dissolved ionic forms while within the earthen dam structure.

In addition, impounded wet tailings are often acidic from mineral exposure to water, oxygen, and bacteria. These impounded fluids have the potential to enter tailing retention dams by capillary action and other hydraulic means, and cause changes in internal pore pressures, voids, particle angularity, and differential consolidation/settlement, etc. throughout the dam during its construction, active use, and raisings. MBT nucleates new mineral and mixed-mineral forms that are stable in acidic conditions, but also addresses the issue of acid-generation in latent mineral residuals and heavy metal leachability.

Mining companies, dam design professionals, contractors and mine operators, and financial institutions/surety companies are generally aware of traditional construction material enhancement that improves the strength and performance of tailing dams. Traditional enhancement of base materials including borrow, overburden, waste rock, and tailings are available for direct use in dam construction with strength improvements provided by supplemental Portland cement, Fly Ash, Cement Kiln Dust (CKD), gypsum, and other pozzolanic material blending and conditioning with the base material where non-traditional material strength enhancing modifiers may include polymers, and structural aids, such as fibers, grids, and fabrics. Unfortunately, and unlike MBT, these well-known strength enhancing supplements do not adequately address the issue of longer-term exposure to AMD, the time-released acidity from naturally degradable acid-generating material within the construction materials. Resultant acid dissolution and degradation of solid material mass within the dam weakens the dam's structure and contribute to its potential or actual failure.

The MBT technology mitigates issues derived from acidity exposure to acidity, and/or the generation of acidic conditions that cause tailing dam risk. MBT:

- Destroys sulfidic and other leachable metal mineral forms and converts them to acid-stable nucleated mineral and mixed-minerals forms
- Renders acid-degradable minerals to dense non-hydroxide forms that are stable in acidic conditions
- Induces chemical bonding of acid-leachable heavy metals carried by fluid into, within, through, and egressing from the dam structure to stable non-leachable hard mineral forms,
- Eliminates risk of hydroxide neutralization and associated strength loss and heavy metal leaching from conventional pozzolanic-hydroxide systems rely on physical binding to create strength and durability against weakening of cementitious agglomerates
- Facilitates uniform settlement and consolidation strength
- Reagents are readily applied in liquid, slurry, or solid forms with a variety of effective low-cost insitu or exsitu equipment processing methods common to most all active mine sites

The MBT process, when used in conjunction with traditional or non-traditional soil strength enhancement methods, will further enhance long-term structural and material integrity by preventing acidity dissolution, and thus provide another cumulative layer of significant risk reduction benefit by increasing tailing dam Safety Factors.

MBT also solves contamination issues related to floodplain toxicity from acute and chronic historic release of leachable heavy metals. Contaminant metals found within impacted host sediments that leach when exposed to water from floods, spates, and other high water or disturbance events can be rendered non-leachable to these conditions by MBT. When coupled with a compatible strength enhancement supplement, the treated material may be used for armoring, or for energy dissipation when coarse aggregate material is processed leaving large intentional stable voids in the placed mass.

MBT additives coupled with traditionally enhanced earthen construction materials provides a practical, yet strategic, layer of protection against tailing dam failure as predictable extreme weather patterns will impact mine sites. Further, the trending extraction of lower grade ore reserves will increase need for larger, better performing, stronger, and sustainable tailing impoundments. Improved dam integrity and improved competency resultant from MBT-benefited enhanced treated tailing dam construction material will reduce risk transferred to (and transfer acceptance by) insurers and surety companies.

The MBT technology owned by HMR Solutions, Inc. of Lakewood, NJ is patents pending in the US and Abroad.