GEOTECHNICAL EVALUATION OF MINING WASTE BY UTILISING AMENDERS

Nishant Singh , Pankaj Kumar , Nitin Singh

Dept. of Civil Engineering, BBDNITM, Lucknow, India

---***---

Abstract- Mining wastes, particularly in the form of waste rocks and tailings, can have major social and environmental impacts. There is a need for comprehensive long-term strategies for transforming the mining industry to move toward zero environmental footprint. "How can the mining industry create new economic value, minimise its social and environmental impacts and diminish liability from mining waste?" This would require cross disciplinary skills, across the social, environmental, technical, legal, regulatory, and economic domains, to produce innovative solutions. The aim of this paper is to review the current knowledge across these domains and integrate them in a new approach for exploiting or "rethinking" mining wastes.

1. INTRODUCTION

Introduction- Each year, mining operations generate large volumes of mining waste. According to the Mining, Minerals, and Sustainable Development Project (MMSD), there are approximately 3500 active mining waste facilities worldwide, consisting of waste rock dumps and tailing dams. The estimated worldwide generation of solid wastes from the primary production of mineral and metal commodities is over 100 billion tonnes per year and can range from several times the mass of the valuable element, such as iron and aluminium ores, up to millions of times for some scarce elements such as gold ore.

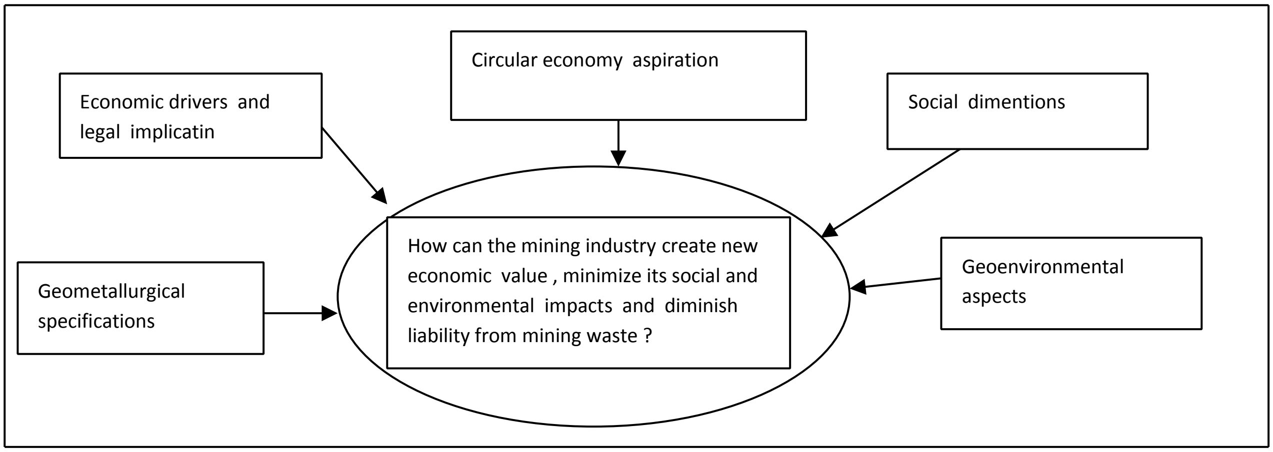
1.2 Objectives

1. Social dimensions: What are the local, regional, and global societal dimensions related to managing mining waste?
2. Geoenvironmental aspects: What are the spatial and temporal geoenvironmental impacts resulting from mining waste, and how can potential liabilities be prevented or substantially mitigated?
3. Geometallurgy specifications: What are the geometallurgical properties to create additional value and improve environmental outcomes in waste from mining and mineral processing?
4. Economic drivers and legal implications: How and what economic drivers should lead the changes in regulatory systems, to transform business approaches for creating value, diminishing risk and drastically mitigating liabilities from mining waste?
5. Circular economy aspirations: How can the mining industry assess and quantify their contribution to the circular economy?

2. PRINCIPLES OF MINING WASTE BY UTILISING AMENDERS

These principles are similar to international sustainable management standards, including the Rio Declaration, Global Reporting Initiative, World
Bank Operational Guidelines, the International Labour Organization (ILO) Conventions, and the Voluntary Principles on Security and Human Rights. These 10 principles cover many topics associated with sustainability, although there is no uniform approach that allows the industry to better integrate sustainability into the design process. Ideally, a sustainability framework should connect corporate and operational level activities and engage with technical professionals. In this

regard, we have identified five key areas, which are aligned with the 10 ICMM principles, that will cover the most important aspects for improved environmental outcomes, and circular economy aspirations. We believe that a dynamic interaction across these five areas will drive the mindset change for re-thinking mining wastes. Over the last few decades, several approaches have emerged that aim to include sustainability aspects across the mining life cycle. Several industry organisations and companies have implemented sustainability principles and strategies for establishing commitment to resource development in a socially and environmentally responsible manner. One such organisation, the International Council on Mining and Metals (ICMM).



3. METHODOLOGY

Volumetrically, mine tailings impoundments are among the largest man-made structures in the world. Furthermore, tailings dam failures account for the major mining-related environmental disasters. A major recent failure happened in January 2019 when Vale's iron ore tailings dam in Brumadinho, Brazil collapsed and killed at least 206 people. Another catastrophic event happened in November 2015 when a tailings dam at the Samarco Mine, Brazil, collapsed, releasing more than 43.7 million cubic meters of water and mine waste, and the resulting mudflow reached the Atlantic coast through the Doce River, along more than 500 km of the river course. In September 2008, 277 people died in an accident caused by iron ore tailings release from a dam break in Shanxi Province, China.

4. CONCEPT OF ECONOMIC DRIVERS AND LEGAL IMPLICATIONS

Economic drivers and legal implications play an important, if not critical, role in establishing new paradigms and allowing innovative approaches to be implemented. Without a proper understanding of the economics as well as the legislative and regulatory context, technically feasible solutions that deliver better outcomes can fail.

5. RE-THINKING MINING WASTE

The mining industry is essential to global economic and social development, and it will continue to be the major resource supplier to our society for the foreseeable future. A strong transition towards recycling and circularity is necessary, but requires some fundamental changes, including appropriate infrastructure, legislation, and favourable economics.

Despite the advancements in tailings management in the last few decades, there is a lack of optimal scenarios for mining waste that deliver overall sustainable societal benefits. Novel initiatives for dealing with mining waste and evidence-based best-practice guidelines for minimising environmental and human health risks are essential to reverse this trend. A transformational perspective to mining waste is necessary and should include a multidisciplinary and integrative approach for exploiting mining waste to create new economic value and move toward a zero environmental footprint.

6. CONSTRUCTION MATERIALS

The internal geometry of the dam is split into three sections, the upstream side, the downstream side, and the porous layer. Waste slurry from processing is pumped to the downstream site, and the unprocessed waste material is trucked to the upstream side. The porous layer consists of coarse gravel excavated from the mine that does not contain any ore. Porous layer mechanical properties will be similar to the coarse material used for the dam, although it will be the larger size of approximately 2.5 to 5cm in diameter with a high porosity. As stated by Richards (2012), approximately 50 percent of all dam failures occur due to uncontrolled seepage (Richards 2012). A geotextile layer will be used to protect the porous layer from internal erosion due to uncontrolled seepage and stop coarse material from being washed out of the dam. Geotextile properties have been modeled such that the control of the phreatic surface and water flow prevent piping, internal erosion, liquefaction, or any other seepage failure throughout the dam. Permeability through the geotextile was assumed to be 1 x 10-8 mm/s. To prevent seepage of waste into the ground water table the starter dam will be constructed on top of a high strength synthetic material such as 30 mil polyvinyl chloride (PVC) or high-density polyethylene (HDPE) 60 mil liner(Rohe 2017).

The synthetic layer has been modeled to be impervious. Research conducted by Bhatia (1996) identified several specific attributes that occur at the interface between the soil layer and the geomembrane liner. Attributes such as:

Friction angle increases with particle size at the interface.

Friction angle increases with increase of flexibility of geomembrane.

Friction angle is higher with PVC than with smooth HDPE

7. OTHER ANALYSIS

Mechanisms that could be potential failures were analyzed. Consideration was made for a scenario of water overtopping the dam but was not researched further due to the minimal potential of such event. The risk of water overtopping the dam is considered minimal since the tailings pond elevation is strictly controlled by the ore processing and water infiltration has been anticipated. Further analysis was conducted on additional phases of the tailings dam. Two other models were analyzed using similar material properties, geometry, and seismic properties as the starter dam. With the addition of each phase the dam elevation grows approximately 15 m. All factors such as the factor of safety, flow through the dam and stability for both slope and seismic activity were all determined to be within tolerance with the rise in dam height. A model was constructed to show the final height of the dam, which is 250 m

8. CONCLUSION

In this paper, we identified and reviewed five key areas, which can form an integrative approach for exploiting or "re-thinking" mining wastes, framed around the circular economy. These include social dimensions, geoenvironmental aspects, geometallurgy specifications, economic drivers, and legal implications. While this dynamic and conceptual approach will be helpful for re-thinking mining waste, much work is still necessary in the research and development phases to identify efficient and effective solutions in each key area. Importantly, feasible solutions, like any credible sustainable development outcome, will require contextual knowledge for each mining operation and/or mining project under consideration.

REFERENCES

[1] Rankin, W.J. Towards zero waste. AusIMM Bull. 2015, 2015, 32–37.

[2] Adiansyah, J.S.; Rosano, M.; Vink, S.; Keir, G. A framework for a sustainable approach to mine tailings management: Disposal strategies. J. Clean Prod. 2015, 108, 1050–1062.

[3] Chryss, A.; Fourie, A.B.; Monch, A.; Nairn, D.; Seddon, K.D. Towards an integrated approach to tailings management. J. South. Afr. Inst. Min. Metall. 2012, 112, 965–969.

[4] Lebre, É.; Corder, G. Integrating industrial ecology thinking into the management of mining waste. Resources 2015, 4, 765–786.
[5] Wellmer, F.W.; Buchholz, P.; Gutzmer, J.; Hagelüken, C.; Herzig, P.; Littke, R.; Thauer, R.K. Raw Materials for Future Energy Supply; Springer: Berlin, Germany, 2018.