Operational design of ramps in open-pit mines considering switchbacks through the assistance of mathematical optimization

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# ABSTRACT

Open-pit mine design is a vital component of strategic mining operations, traditionally carried out through a labor-intensive "traditional design" approach. This study introduces a two-step methodology to streamline the creation of operational mine designs while incorporating 180-degree ramp turns, or "switchbacks." The first step employs mixed-integer linear programming to generate a block-supported mine design, where the layout is represented using discrete blocks. In the second step, this preliminary design is transformed into an operational mine design, referred to as the "aided design." CAD software assists mine designers in replicating the ramp paths derived from the block-supported design. Remarkably, the aided design achieves outcomes comparable to those of a human expert, with minimal percentage differences in value. This demonstrates the method’s effectiveness in maintaining design quality while significantly reducing the time and resources needed for mine planning. By lowering reliance on individual expertise, this approach frees resources to explore various design scenarios, such as optimal switchback placement and surface ramp configurations, allowing for better-informed decision-making. Although the methodology offers substantial advantages, the conclusions are case-specific and depend on factors such as the block model, pushback geometry, economic parameters, and technical constraints. Nonetheless, this study highlights the potential of combining optimization tools and CAD software to enhance the efficiency and consistency of open-pit mine design processes. The proposed methodology not only simplifies the design process but also opens new possibilities for analyzing diverse mine configurations. The semi-automatic design positions itself as a valuable tool for mine planning, delivering substantial advantages to mine designers.