# Development of a Simulation-Integrated Mine Road Quality Index (MRQI) for Efficient Dispatching Operations in Surface Mines

Sude Nil Topal1, Ahmed Elshahawy2 and O. Gölbaşı3

1. Student, Middle East Technical University, 06690. Email: nil.topal@metu.edu.tr

2. Sales Export Specialist, Noksel Steel Pipe, 06690. Email: ahmedelshahawy@gmail.com

3. Associate Professor Dr., Middle East Technical University, 06690. Email: golbasi@metu.edu.tr

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# ABSTRACT

Haul roads are critical to the safety, efficiency, and productivity of surface mining operations. The deterioration of haul road functionality, whether partial or complete, can result in significant challenges such as production delays, increased wear on machinery, and induced safety risks, all of which may disrupt or even halt dispatching activities. In many cases, the construction of mine roads relies on experience-based practices rather than standardized methodologies. The absence of systematic and standardized approaches in haul road construction contributes to the emergence of various operational problems, as the frequency and severity of uncertainties increase. These issues often appear as potholes, slip cracks, and uneven surfaces on the road.

This study aims to address these challenges by developing a standardized framework, the Mine Road Quality Index (MRQI), designed to assess and improve the quality of mine roads. The methodology integrates fuzzy logic, fault tree analysis, and discrete event simulation to analyze and prioritize the uncertainty factors that influence road quality and performance. To achieve this, a Fuzzy Fault Tree Analysis (FFTA) integrated with expert panel is conducted first to evaluate fifteen key uncertainty factors in five main categories: structural design uncertainties, functional design uncertainties, management uncertainties, geometric design uncertainties, and geological uncertainties. These factors are assessed based on their alignment with both planned and actual road conditions, as well as their frequency and severity in contributing to road failures and impacting production rates.

Constructed FFTA allows the development of a Discrete Event Simulation (DES) model for a more in-depth evaluation of uncertainties affecting road quality and for exploring road improvement strategies by integrating the MRQI into a dispatch algorithm. This integrated approach offers a systematic approach to simulate and predict road performance across various scenarios, enabling improved operational outcomes.