

Study on Road User Safety Issues in Road Construction Work Zones in Sri Lanka

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Abstract

Critical road user safety deficiencies within road work zones across Sri Lanka are addressed in this research, where the construction and maintenance of transportation infrastructure significantly influence risk exposure. A comprehensive nationwide analysis revealed that widespread non-compliance with the national guidelines on traffic control for road work areas primarily contributed to elevated hazards. Core safety challenges identified include inadequate traffic control measures, insufficient illumination, absence or inadequacy of warning signage, inconsistent enforcement of safety protocols, and adverse geographic or environmental conditions. Crucially, the study diagnosed a fundamental methodological gap: inconsistent risk assessment by consulting engineers due to varying levels of expertise, subjective judgment, and the lack of a standardized, quantitative framework. This inconsistency impedes accurate identification of risk levels (high, medium, low) and hinders effective mitigation planning. To overcome these limitations, this study introduces a novel, intelligent risk assessment platform leveraging machine learning (ML) for the automated, objective, and consistently classified work zone safety levels. The core innovation lies in integrating mathematical rigor with real-world engineering validation. The methodology employed a mixed-method strategy across 40 representative work zones. Data encompassed detailed field surveys capturing physical conditions, traffic parameters, and compliance metrics, alongside expert insights. Risk was quantified along three key dimensions: severity, exposure, and likelihood. These indices were derived using a weighted Likert-scale system applied to observed risk factors. The calculated risk index level was identified through a clustering algorithm (K-means), which was then applied to these indices to empirically define high, medium, and low-risk categories, providing a data-driven baseline. Subsequently, multiple supervised ML algorithms were trained and optimized using the field data and the cluster-derived risk labels as ground truth. The primary task was classification into the predefined risk categories based on the input risk factor assessments. Crucially, model validation incorporated rigorous comparison against independent safety evaluations conducted by experienced engineering professionals. This ensured the ML platform's outputs aligned with practical, on-ground engineering judgment, bridging the gap between algorithmic prediction and real-world applicability. Results indicated a concerning prevalence of medium to high-risk classifications across the surveyed zones, confirming significant non-compliance with national standards, particularly regarding signage, lighting, and protective barriers. Among the ML models evaluated, the random forest algorithm demonstrated superior performance, achieving the highest classification accuracy while maintaining strong interpretability through feature importance analysis, making it optimal for field deployment. This research delivers a validated, intelligent ML-based platform that provides scalable, consistent, and objective safety assessments for road work zones in Sri Lanka. It directly

addresses the identified problem of inconsistent engineer evaluations by offering a standardized, data-driven methodology. The platform calculates a composite risk index for work zones by integrating predictions from a random work zone model with an audited work zone database. This index, derived from input risk factors, classifies work zone risk into three levels: low ($0 \leq \text{index} < 0.204$), medium ($0.204 \leq \text{index} < 0.298$), and high ($0.306 \leq \text{index} \leq 1$). Using the established classification levels and developed platform, a comprehensive risk identification system was formulated based on variations in the risk index and its relationship with key factor combinations. This approach enables a dual-path risk identification method that enhances accuracy and reliability. The platform functions as a powerful decision-support tool for engineers, policymakers, and contractors, facilitating targeted and data-driven safety interventions. By integrating advanced analytics with domain expertise validation, the study delivers a significant technological advancement in road safety management. This robust solution holds particular relevance for Sri Lanka's extensive ongoing and planned highway infrastructure projects, supporting more informed and effective safety strategies.

Keywords: *machine learning, safety, road construction work zones, rural, urban*

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