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Applying Inherently Safer Design Principles to Hazard Identification and Risk Assessment in Metro Infrastructure Projects: A Design-Centric Approach

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Abstract: *Developing an efficient rail or road transport system involves building viaducts to ensure safe and smooth traffic flow without congestion. Viaducts also help link existing networks across challenging terrains and allow for better utilization of limited land. Constructing rail and road infrastructure often involves working in dangerous conditions, and while ground-level work poses risks, these risks are significantly higher when construction takes place above ground level According to estimates from the Occupational Safety Administration (OSHA) in the UK, over 10% of workers engaged in viaduct construction experience accidents, which can range from minor injuries to fatalities. Hence, it is crucial to reassess current safety protocols and explore ways to enhance the existing safety standards. Reducing injuries begins with identifying hazards and evaluating associated risks. Hazard Identification and Risk Assessment (HIRA) methods are used to detect potential dangers at construction sites and to determine their level of risk. While HIRA is widely adopted across the construction industry and forms part of the overall management system, certain critical elements that could improve its effectiveness are often overlooked. As a result, some inherent hazards go unnoticed, leading to accidents during project execution. These gaps impact the project both directly and indirectly, contributing to substandard safety performance on-site and fostering a weak safety culture*

This thesis examines the current safety practices and standards implemented in the viaduct construction industry. It identifies the factors contributing to the high accident rate and offers recommendations to enhance worker safety, ultimately aiming to significantly reduce the number of injuries. Several aspects often missed—whether deliberately or unintentionally—during hazard identification and risk assessment using HIRA have been recognized and incorporated to enhance the existing methodology. A comprehensive framework has been developed, based on twelve key considerations identified through an in-depth review of various method statements. Each of these considerations includes six subcategories or focus areas. The quantification of each area is carried out through data analysis, studies, and surveys conducted at the construction site. These considerations have been quantified and risk multiplication factor (RMF) is generated. Finally, a modified risk level (MRL) is obtained by multiplying initial risk level with RMF. The control action plan can be updated based on the revised Maximum Risk Level (MRL). By applying this risk assessment framework, several areas or concerns—often missed by traditional HIRA methods—can be effectively identified. The framework also incorporates a color-coded risk rating system: red indicates a critical level where all work must halt until corrective actions are taken; yellow signifies the need for immediate attention; and green represents an acceptable risk level. This framework is applicable throughout the entire construction process, from site selection to project execution. Its implementation can either prevent accidents entirely or significantly reduce their occurrence during construction activities

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