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A Framework Of BIM-Based Digital For Fatigue Damage Evaluation In Railway Steel Bridges

Idilson Nhamage[a], José Campos e Matos[b], Dang Ngoc-Son[c]

[a]*Faculty of Engineering of University of Porto, Porto, Portugal*
[b,c]*ISISE-School of Engineering of University of Minho, Guimarães, Portugal*

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The evaluation of bridge behavior assisted by Building Information Modelling (BIM) has currently been investigated, partly due to the pressure imposed by the globalization of digitalization. Regarding the structural stability of Railway Steel Bridges (RSB), it is known that one of the failure modes is caused by fatigue damage, and a continuous monitoring of this type of damage is, therefore, essential. Although significant progress has been made in damage identification/detection methods, including fatigue damage, information about these anomalies, such as their monitoring over time, can hardly be expressed or visualised, for example, in the infrastructure in question using current analysis methods.

To address these and other challenges, BIM has been increasingly adopted in new domains. Currently, advances and its growing use in other infrastructures, including bridges and railways, are evident (Queiroz et al., 2023). The surge in BIM adoption stems from its inherent capacity to revolutionize the way we capture, represent, and manage complex data associated with structural health (Inzerillo et al., 2023). In the context of assessing and monitoring anomalies like fatigue damage, BIM provides a versatile platform that goes beyond the limitations of traditional analysis methods. Its three-dimensional modeling capabilities, coupled with the integration of real-time data, offer a more holistic and dynamic approach. This not only enhances the precision of anomaly representation but also allows for continuous monitoring and analysis, thereby significantly advancing our capabilities in infrastructure management and maintenance. However, the process of integrating information still raises significant debates (Yamane et al., 2022), from the perspective of the type and scope of the information to be integrated (e.g., whether it is internet-based network information or how such information is visualised, etc.). Recognizing these potentialities, a significant current challenge lies in establishing processes capable of automatically and continuously enriching BIM models with information regarding the state of specific assets. This study presents a framework for a BIM-Based Digital Model tailored to enhance the assessment of fatigue-induced damage in RSB.

Global Framework of Digital Model

The comprehensive framework of the Digital Model is thoughtfully outlined in Figure 1, encapsulating a sophisticated approach to managing input information and integrating results derived from fatigue calculation tools. At its core, the model leverages BIM as the foundational platform, orchestrating a harmonious interplay between diverse data sources to enhance the evaluation of RSB. The essence of BIM lies in its role as a shareable and collaborative database, housing pertinent information crucial for fatigue damage assessment. This includes a spectrum of data such as inspection records, dynamic properties of the bridge, rail traffic loads, and a meticulously crafted three-dimensional geometric representation of the bridge. The collaborative nature of BIM fosters an environment where multiple stakeholders can contribute and access information seamlessly, enhancing the accuracy and comprehensiveness of the Digital Model. To realize the geometric aspect of the Digital Model, AUTODESK REVIT® software emerges as a cornerstone, acknowledged for its prominence in digitizing building assets (Jiang et al., 2021). Utilizing REVIT, the 3D geometric model of the bridge is created. Furthermore, REVIT facilitates graphical visualization of fatigue damage and related information, providing a dynamic and intuitive representation of the bridge's structural health. The intricate task of calculating fatigue damage under various scenarios is entrusted to MATLAB® software, a versatile tool capable of handling complex calculations. MATLAB's prowess allows for a robust exploration of different scenarios, considering diverse factors influencing fatigue damage in RSB. Simultaneously, the dynamic properties essential for these calculations are computed using ANSYS® software, renowned for its capabilities in structural analysis and simulation. This entire process culminates in the organization of the Digital Model into three distinct yet interrelated modules: the Input Module, the Calculation Module, and the Output Module. The three modules are represented in the framework.

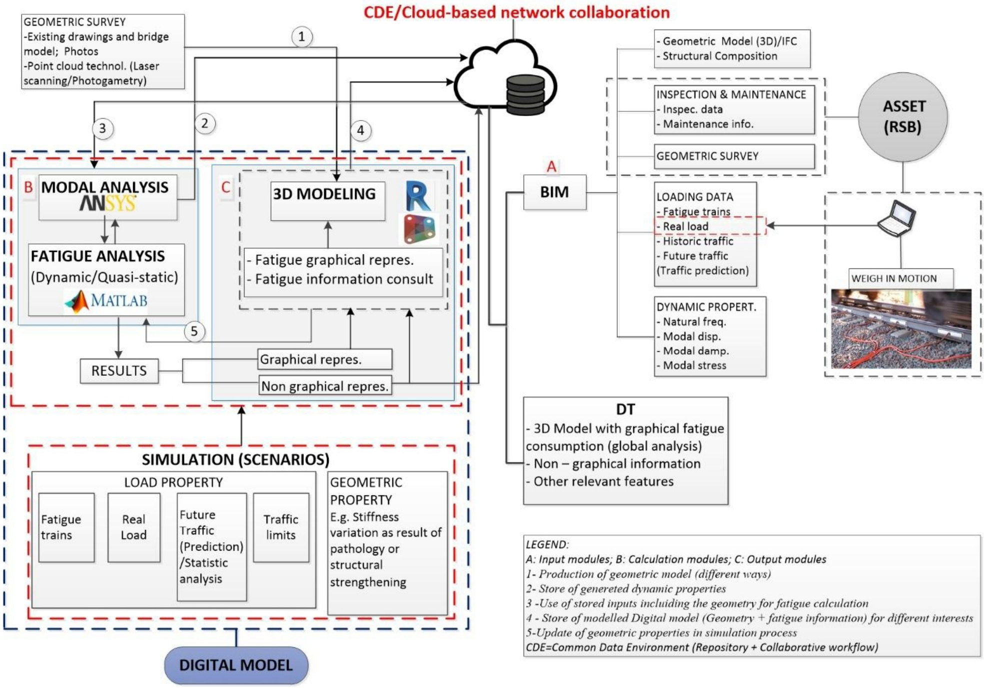

Fig. 1. Framework of the proposed Digital Model.

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