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Editorial

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It is my pleasure to publish the July issue (3rd issue) of Vol. 2 of the *International Journal of Bridge Engineering, Management and Research*. You can find detailed information about the journal in the inaugural issue, published in September 2024. In this issue of the journal, we are pleased to bring to you eight papers on innovative areas of bridge engineering, with several papers focusing on artificial intelligence (AI) in bridge engineering.

In the paper entitled "**Advancing Bridge Infrastructure Management through Artificial Intelligence: A Comprehensive Review**," the authors Kumar and Agrawal present a critical review of literature and case studies on the potential impact of artificial intelligence on bridge infrastructure management. This comprehensive review explores how recent advancements in Artificial Intelligence (AI), including computer vision (CV), natural language processing, deep learning (DL), predictive modeling, robotics, and large language models (LLMs), which are revolutionizing the entire bridge management lifecycle. AI-based systems are examined for automated condition detection and rating, data-driven deterioration forecasting, and maintenance prioritization using multimodal data inputs. Special emphasis is placed on the LLMs for extracting actionable insights from unstructured inspection records and facilitating automated decision support. In addition, the review covers AI-driven training and quality assurance tools for inspectors, and demonstrates the potential of LLM-powered bots for real-time bridge condition communication. By benchmarking these innovations against traditional practices, this paper identifies current capabilities, integration challenges, and future research directions essential for realizing intelligent, sustainable, and scalable bridge infrastructure management.

In the paper entitled "**Artificial Intelligence in Bridge Engineering and Management with Emphasis on Construction Phase**," the author Alsharqawi has presented a comprehensive assessment of AI applications, specifically machine learning (ML), DL, and CV, employed in bridge construction planning, scheduling, monitoring, quality assurance, and safety management. Given the growing complexity of bridge projects and the persistent demands for enhanced safety, efficiency, and cost-effectiveness, integrating intelligent, data-driven methodologies has become essential. Utilizing a mixed-methodology approach, this study combines scientometric and systematic literature reviews to critically analyze peer-reviewed publications spanning the years 2000–2025. The findings indicate substantial advancements in AI techniques, demonstrating notable improvements in resource optimization, risk prediction accuracy, and proactive safety management. However, the implementation of AI in bridge construction also faces challenges, such as high computational resource requirements, data quality issues, model scalability concerns, and integration complexities. By identifying key research trends, technological benefits, and existing limitations, this paper contributes valuable insights and proposes future research directions to enhance the practical integration of AI, ultimately aiming to improve the resilience, reliability, and longevity of bridge infrastructure.

In the paper entitled "**Prestressed UHPC Beam Flexural Capacity Prediction Improvement with Constraint-Guided Neural Networks**," the authors Qu, Teng, Zhu, Qu, and Wu have presented a constraint-guided neural network approach to address prediction accuracy degradation in ML models when tested on unseen data after training with limited datasets, while simultaneously enhancing the generalization capabilities of conventional mechanical equations. The proposed model predicts the flexural capacity of prestressed ultrahigh-performance concrete (UHPC) beams using a small experimental dataset collected from the literature. Physical constraints incorporated into the model include geometrical relationships, reinforcement

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Discussion period open till six months from the publication date. Please submit separate discussion for each individual paper. This paper is a part of the Vol. 2 of the International Journal of Bridge Engineering, Management and Research (© BER), ISSN 3065-0569.

ratio limitations, and strength correlations. Comprehensive performance comparisons demonstrate that the CGNN model outperforms traditional ML methods—including back propagation neural networks, categorical boosting, extreme gradient boosting, random forests, and decision trees—as well as conventional predictive equations. The CGNN exhibits superior performance across multiple metrics: mean ratio, coefficient of variation, mean relative error, coefficient of determination, maximum ratio, and minimum ratio, while maintaining consistent accuracy between training and testing phases. Model interpretability is achieved through SHAP (SHapley Additive exPlanations), and a user-friendly graphical user interface has been developed to facilitate adoption by UHPC design practitioners.

In the paper entitled "**Integrating Graph Networks and RNNs for Time Predictive Bridge Asset Management and Risk Mitigation**," the authors Saha, Sowemimo, Chorzepa, and Birgisson have introduced a data-driven bridge asset management framework that integrates artificial intelligence, geographic information systems, and graph-based network modeling. A comprehensive graph network representing Georgia's National Highway Freight Network was developed using geospatial coordinates and roadway intersection data to evaluate structural and topological criticality at the network level. Structural condition forecasting of individual bridges was conducted using advanced recurrent neural network (RNN) models, including long short-term memory and gated recurrent unit architectures. These models predict future deck condition ratings based on historical element data, average daily truck traffic, age, maximum span length, and the number of main-unit spans. The integrated RNN-driven, graph-based framework uncovers key patterns influencing bridge performance and identifies topological weaknesses that may compromise freight mobility. This analysis enables risk-informed prioritization of maintenance, repair, and replacement strategies, supporting a shift from reactive to predictive decision-making and enhancing the resilience of critical transportation infrastructure. Findings highlight the framework's utility in evaluating the impacts of disruptive events on bridge closures and network accessibility.

In the paper entitled "**A Digital Twin Framework for Real-Time Monitoring and Full-Field Analysis of Bridges**," the authors Zhao, Wu, Xia, and Xia have proposed an integrated digital twin framework to address the limitations of traditional finite element methods for real-time analysis through a synergistic combination of structural health monitoring and advanced ML techniques. A footbridge with an SHM system is used as the testbed. A novel transformer-based surrogate model named SAE-Transformer is developed for real-time calculation of three-dimensional full-field temperature distribution and thermal stress of the entire bridge. One year of bridge data was adopted for training the SAE-Transformer. Equipped with a sequence-aware embedding module and a SwiGLU activation layer, the SAE-Transformer model reduces the temperature prediction error by 39% and the stress estimation error by 45% compared to the state-of-the-art DL models. Moreover, the modal superposition technique is adopted to recover the full-field vibration of the bridge using monitoring data from sparse sensors, enabling real-time visualization at 50 fps. The implementation demonstrates that the proposed ML-empowered technique realizes real-time full-field analysis of large-scale civil structures for the first time.

In the paper entitled "**An Adversarial-Based Method for Knowledge Transfer Across Bridges**," the authors Giglioni, Venanzi, and Ubertini have noted that data-driven ML methods for bridge health assessment often face limitations due to the scarcity of labeled data, particularly related to damaged conditions, which are often difficult, expensive, or even impossible to obtain in practice. To address this challenge, transfer learning offers a promising solution by leveraging knowledge gained from one structure (or domain), with sufficient labeled data, to identify damage on a different but related structure where labeled data are limited or unavailable. In this study, we propose a domain adversarial neural network-based method to enhance damage classification performance across different bridge structures. Using the natural frequencies collected over long-term monitoring campaigns, the ML model is trained with an adversarial strategy to learn damage-sensitive and domain-invariant features for improving generalization to new structures with minimal additional data collection. To validate the methodology, transfer learning results are analyzed by first considering two post-tensioned concrete bridges, the Z24 bridge and the S101 bridge, and afterwards their finite element models, where different damage scenarios in terms of localization and severity are simulated. Furthermore, the performance of the proposed method is compared with different transfer learning approaches previously applied in the same structural health monitoring (SHM) context. The improvement of damage classification results via transfer learning highlights the potential of domain-adversarial learning to advance scalable SHM strategies for bridge networks.

In the paper entitled "**Precision Assessment of Reinforced Concrete Pier Resilience under High-Velocity Vehicle Impact Using an Energy-Based Analytical Model**," the author Roy has investigated the energy dissipation behavior of reinforced concrete piers using a spring-action model that includes concrete's contribution—often neglected in traditional analyses. Monte Carlo simulations, with and without concrete's effect, evaluate failure probabilities and inform post-impact energy dissipation equations, validated through uncertainty analysis. Findings reveal concrete's vital role in energy absorption, structural reliability, and damage prediction, coupled by executing risk analysis. This present research offers an insight to enhance design tools and support code calibration for dynamic loading conditions, fostering more robust and efficient designs under short–duration, high-strain-rate loads.

In the paper entitled "**Innovative Repair of Transversely Cracked PPC Bridge Deck Girder Using Precast Prestressing Plates with Shape Memory Alloys**," the authors Gunasekaran, Khan, and Andrawes propose an innovative repair of transversely cracked PPC bridge deck girders using shape memory alloy precast prestressing plates (SMA-PPPs). The feasibility of applying external prestressing using voided SMA-PPPs was investigated experimentally by affixing them to a mortar block. The mortar block successfully developed the expected prestress and exhibited a 50% improvement in capacity compared to a control block under a four-point bending test. A numerical investigation was also conducted to assess the improvement in capacity and load rating of a transversely cracked PPC deck girder repaired using voided SMA-PPPs. Furthermore, a parametric study was conducted to assess the influence of the width of transverse cracks, length of PPP, and the SMA–concrete area ratio on the improvement in the capacity and load rating of the repaired girders. The numerical analysis demonstrated a 36% improvement in the capacity of the repaired girders, which resulted in a 40.91% improvement in the load rating.

With this editorial note, it is also my pleasure to invite you to submit your papers addressing research with new and substantial contributions in bridge engineering to the *International Journal of Bridge Engineering, Management and Research*. The journal is committed to a prompt peer review process and TO online publication of the paper within 4 weeks of acceptance. We are also committed to completing our peer review process within 90 days of paper submission. You are invited to submit your papers for the next issue of the journal in September 2025 by July 31, 2025.