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Integrating AI and statistical methods for enhancing civil structures: current trends, practical issues and future direction
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Abstract
The integration of artificial intelligence (AI) and statistical methods has revolutionized civil engineering by enhancing accuracy, efficiency, and reliability in various processes. This review systematically examines how advanced optimization techniques, including artificial neural networks (ANNs), Design of Experiments (DOE), and fuzzy logic (FL), are transforming civil engineering practices. It emphasizes the significant roles these methods play in addressing modern challenges such as structural health monitoring, damage detection, seismic design optimization, and concrete condition assessment. The review delves into case studies and real-world applications, showcasing the potential of these methods to create more resilient, sustainable, and cost-effective infrastructures. It critically examines the limitations and scalability of these techniques, identifying gaps in current research and practical challenges in real-world applications. The investigation also highlights the need for substantial computational resources, data privacy, security, and software interoperability. By addressing these issues, the review not only shows advancements in optimization techniques but also outlines future research directions, aiming to bridge the gap between theoretical developments and practical applications in civil engineering. This review serves as an essential resource for researchers, professionals, and policymakers interested in leveraging optimization techniques to advance civil engineering practices. © 2025, Gruppo Italiano Frattura. All rights reserved.

Author Keywords
Artificial Intelligence (AI); Civil Structures; Design of Experiments (DOE); Fuzzy Logic; Optimization Techniques

Index Keywords
Cost engineering; 'current, Artificial intelligence, Civil structure, Design of experiment, Efficiency and reliability, Engineering practices, Fuzzy-Logic, Optimization techniques, Practical issues, Real-world; Seismic design

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