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Ph.D. DISSERTATION DEFENSE

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Title:	Artificial Intelligence Powered Design and Monitoring of Civil Structures and Metamaterial
Chairperson:	Prof. Yi Bao, CEOE, Stevens Institute of Technology.
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ABSTRACT

This dissertation focuses on the application of artificial intelligence, computational optimization, and advanced materials to enhance the design, monitoring, and resilience of civil infrastructure. Traditional methods for infrastructure design and maintenance are inefficient and labor-intensive, prompting the need for AI-driven solutions to automate and optimize structural performance. The research has structured three main themes: (i) automated optimization of modular and composite materials, (ii) adaptive and reconfigurable connections for improved resilience, and (iii) intelligent structural health monitoring using distributed sensing. The dissertation addresses six research objectives. First, a many-objective optimization framework is developed for Lego-inspired modular blocks, maximizing load capacity and stiffness while minimizing material use. Second, an AI-driven framework is introduced for architectured polymer-concrete composites (APCC) to improve flexural strength and toughness. Third, an active learning-based approach is proposed for rotating-reentrant metamaterials (RRMs) to optimize mechanical properties. Fourth, a three-level optimization method is implemented for adaptive interconnections, enabling structures to adjust fixity factors under seismic loads, reducing drift and spectral acceleration. Fifth, a distributed fiber optic sensing (DFOS) framework is developed for real-time scour monitoring of subsea cables, validated through strain measurements and finite element modeling. This dissertation contributes to advancing civil engineering by offering innovative machine learning techniques, ultimately leading to more efficient, cost-effective, and reliable infrastructure solutions.