PCI Research Fellowship Topics of Interest

Introduction

The precast concrete industry has long been recognized for its ability to deliver durable, high-quality structural systems through controlled manufacturing. As the built environment evolves, new challenges and opportunities are emerging that require continued innovation in materials, structural systems, manufacturing technologies, and sustainability.

The Precast/Prestressed Concrete Institute (PCI) supports research that advances the capabilities of precast concrete and expands its role in the future of construction. Through its Fellowship program, PCI encourages research that addresses important industry challenges while fostering new ideas that can transform the way precast concrete is designed, manufactured, and used in the built environment.

The research themes below highlight areas where innovation has the potential to significantly improve the resilience, sustainability, efficiency, and performance of precast concrete systems.

These themes reflect areas where the precast industry sees significant opportunity for innovation and where academic research can play an important role in advancing both engineering practice and construction technology.

The research directions listed below are provided as examples of areas of interest. Fellowship proposals are not limited to these topics, and innovative ideas addressing other challenges facing the precast industry are encouraged.

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1. Component Behavior, Design Methods, and Standards Development

Research focused on advancing design methodologies, detailing practices, and code provisions for precast concrete systems to improve clarity, reliability, and consistency in engineering practice. Topics that support further development of ACI/PCI CODE-319, other PCI Specifications, or the PCI Design Handbook are of particular interest.

Example research directions include:

Component design and detailing
Development and refinement of design and detailing approaches for precast concrete components and connections to improve constructability, performance, and consistency.

Standards development and design provisions
Research supporting the development, validation, and refinement of design provisions in industry standards and building codes related to precast concrete components and systems (especially ACI/PCI CODE-319).

Design and behavior of insulated precast wall panels
Improved understanding of structural behavior, load transfer mechanisms, and detailing requirements for precast insulated wall panels used in structural and cladding applications. Topics that support further development of ANSI/PCI 150 (Specification for the Design of Precast Concrete Insulated Wall Panels) are of particular interest.

Support for development of PCI Specifications
Research contributing to the development of future PCI standards, including ANSI/PCI 128 (Specification for Glass-Fiber-Reinforced Concrete Panels) and ANSI/PCI 142 (Specification for Precast, Prestressed Concrete Piles).

Design for fire, blast, and other extreme events
Investigation of the behavior, detailing, and design approaches for precast concrete components and systems subjected to fire, blast, or other extreme events, including strategies to improve robustness, resilience, and overall system performance.

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2. Resilient Lateral Systems

Research focused on improving the performance, reliability, and design methodologies of precast concrete lateral-force-resisting systems subjected to seismic, wind, and other extreme loading conditions.

Example research directions include:

Connection systems for precast lateral systems
Development and evaluation of connection systems for precast walls, frames, and other structural components capable of sustaining large cyclic deformations while maintaining reliable load paths and energy dissipation.

System-level behavior of precast structures
Improved analytical and experimental understanding of how joint flexibility, connection behavior, and component interaction influence the global response of precast structural systems.

Resilience and post-event performance of precast structures
Research exploring how precast systems can maintain functionality or be rapidly repaired following extreme loading events.

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3. Low-Carbon and Advanced Materials

Research aimed at reducing the environmental impact of precast concrete while maintaining the durability, strength, and production efficiency required for precast manufacturing.

Example research directions include:

Low-carbon concrete mixtures for precast production
Investigation of alternative cementitious systems and carbon-reducing technologies compatible with the rapid production cycles required for precast manufacturing.

Novel cement technologies
Evaluation of emerging cement systems and alternative binders that have the potential to significantly reduce embodied carbon while maintaining compatibility with precast production and structural performance requirements.

Advanced reinforcement systems
Evaluation of fiber reinforcement, non-metallic reinforcement, or hybrid reinforcement systems that improve durability, reduce material usage, or enhance structural performance.

Durability and service life of low-carbon concrete systems
Investigation of the long-term durability and structural performance of low-carbon concrete mixtures used in precast manufacturing, including improved methods to predict service life and quantify life-cycle environmental benefits.

Data-driven optimization of low-carbon concrete mixtures
Development of digital tools, predictive models, or AI-assisted methods to optimize concrete mixture proportions, curing conditions, and production parameters to minimize embodied carbon while maintaining performance requirements for precast manufacturing.

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4. Digital Design, Automation, and Smart Manufacturing

Research exploring how digital technologies can transform the design, manufacturing, and inspection of precast concrete systems.

Example research directions include:

Automation and robotics in precast manufacturing
Development of robotic systems or automated processes to improve efficiency, safety, and quality in repetitive fabrication tasks such as reinforcement placement, form preparation, and finishing operations.

Digital inspection and quality control
Development of digital technologies such as laser scanning, machine vision, or augmented reality to improve dimensional inspection, defect detection, and quality control in precast manufacturing.

Integration of digital design, drafting, and manufacturing workflows
Research aimed at integrating structural analysis models, BIM models, precast detailing systems, and plant production systems to enable model-driven design, automated detailing, and more efficient precast manufacturing.

Data-driven and predictive manufacturing systems
Application of machine learning, digital twins, or advanced data analytics to monitor production processes, optimize scheduling, improve quality control, and enhance manufacturing efficiency in precast plants.

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5. Next Generation Precast Building Systems

Research exploring innovative structural and architectural systems that expand the capabilities and market opportunities for precast concrete.

Example research directions include:

Ultra-thin or lightweight precast structural systems
Development of structural systems utilizing ultra-high-performance concrete or other advanced materials to enable thinner, lighter, and more efficient precast components.

Efficient structural systems for emerging building types
Development of precast structural systems that improve efficiency, constructability, and performance for building types where precast construction offers significant advantages.

Integrated building systems
Development of precast systems that integrate structural, mechanical, thermal, or building envelope functions to improve building performance and reduce construction complexity.

High-performance building envelope systems
Development of advanced precast façade or wall systems that improve thermal performance, durability, constructability, and architectural flexibility.

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6. Infrastructure and Transportation Applications

Research aimed at improving the design, durability, constructability, and lifecycle performance of precast concrete elements used in transportation infrastructure.

Example research directions include:

Improved design methodologies for prestressed concrete bridge elements
Research to improve the efficiency and reliability of design approaches for prestressed bridge girders and related structural elements.

Interface behavior between precast and cast-in-place systems
Improved understanding of shear transfer and load sharing between precast and cast-in-place concrete components.

Accelerated bridge construction systems
Development of precast systems that improve the speed, safety, and durability of bridge construction.

Durable connection systems for transportation structures
Development of connection details that improve long-term durability and reduce maintenance requirements.

Repair, rehabilitation, and replacement strategies for precast infrastructure
Development of precast-based repair, strengthening, or replacement systems that improve the speed, durability, and constructability of infrastructure rehabilitation while minimizing traffic disruption and lifecycle costs.