PCI Research Needs List March 2025

Category	Subject	Comments
Component Design and Detailing	Eccentrically loaded concrete corbels	There is plenty of design guidance from ACI and PCI for the design of concentrically loaded corbels (concentric in the width of the corbel), supported by many peer-reviewed research articles. However, there is no guidance from ACI or PCI if the load is eccentric (resultant of load is closer to one side of corbel than the other), and no peer-reviewed research articles seem to address this issue. 3D brick modeling with OpenSees, including material non-linearity, seems to indicate that the capacity of concrete corbels is diminished as the eccentricity is increased, parabolically, but no real world physical testing is available to validate the digital models. This seems to be a pressing issue, as eccentrically loaded corbels are quite common in precast construction.
	Minimum concrete strength at prestress release **(priority)**	Determine minimum concrete strength requirements at release of prestressing. With carbon reduction initiatives, explore relaxing current requirements.
	Components that require more prestress than a plant can pull on beds/abutments	Methodology for strength and stresses for combined pretention (with strain compatibility) and unbonded post-tensioning (without strain compatibility)
	Strength reduction factor for seismically confined columns	The compression-controlled phi factor for a tie confined column is 0.65 while a spiral confined column is 0.75 due to improved confinement. The tied column factor of 0.65 was based on #3 or #4 ties at roughly 16" o.c. wrapping every other leg. A seismically tied and confined column today has #5 ties at 4 inches o.c. This added confinement, for seismic ductility, provides much more reliable column capacity. A seismically confined column should have similar reliability to a spiral confined column. Investigate if a higher factor is justifiable in seismically confined (tied) columns.

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Component Design and Detailing	Dowel action as an alternative to shear friction	ACI 318 does not cover dowel action in connections. New provisions in ACI 318-19 add shear-lug design that shares strength with studs with dowel mechanism that is not explicitly defined.
	Use of high strength reinforcement for spirals in prestressed piles	Permit allowable yield strength of spirals to increase to 120 or 150 ksi.
	Effects of partial debonding of prestressing strands	Include consideration of lightweight concrete
Seismic	Effective stiffness of vertical panel groups mechanically connected across vertical joints **(high priority)**	Concern is how to evaluate the effective stiffness of such panel groups considering the flexibility of connections across vertical joints for proper modeling of systems. ACI 318 permits the design of special moment frames of precast concrete considering strong or ductile connections. The Code does not afford the same consideration for connections in vertical joints of precast concrete walls. The design of strong or ductile connections requires the characterization of wall stiffness as well as strength and/or ductility in these connections for design to be standardized.
	Improved diaphragm connection performance when subject to earthquake loading (**priority**)	Connection characteristics are defined – new connections need to be qualified. In particular, high deformability connections in shear and tension are needed for more severe SDC's. Develop a ductile welded chord connector with high deformability.
	Refine Ω_v for diaphragm design (**priority**)	This factor currently makes untopped diaphragms impractical in regions of high seismicity. This factor was derived from a parametric study completed during the DSDM research. This is having a large impact on precast systems a more in-depth study is justified to refine or validate this factor.

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	Debonded length of deformed reinforcement to prevent brittle fracture at mechanical splices.	Spliced bars at horizontal joints and at bars welded to plates at welded connections are subject to fracture due to strain demands imposed on limited bar length. Determine the optimal length to debond the reinforcement to allow deformation over longer bar length without excessive reduction in connection stiffness.
	Refine diaphragm connector test protocols	Consider modifying diaphragm connection test protocol to consider shear transfer with larger joint opening to permit ductile connection behavior in shear to be considered with shear deformation at joints to eliminate the need to increase shear force in diaphragm design.
Seismic	Enhanced Joint Shear in Hybrid Moment Frame Columns	Currently the HMF system comes at a cost premium to a Concrete Special Moment Resisting Frame(SMRF). This cost is mostly since columns in HMF systems need to be larger to accommodate the larger joint shear as well as the reduced column cross section due to the duct. If we could come up with a way to enhance the joint shear of the column by 25% +/- it could help make this system more cost compatible with an emulative SMRF
	Connections at wall corners for Intermediate Precast Walls used for shear walls where there is a shear flow requirement to develop overturning resistance across a joint	Anchorage to concrete requirements in Section 17.10 of ACI 318 are excluded in plastic regions in the seismic force-resisting system. Steel yielding is required as the limit state for intermediate wall connections. Development and testing is needed.
	Seismic Design for wall panels with horizontal joints without minimum reinforcement crossing the joints	ACI 318 permits the design of special precast concrete shear walls that meet the requirements for CIP special structural walls and the connection requirements for intermediate precast concrete structural walls. An interpretation of these provisions is that the joints between walls are connections, and do

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Seismic		not require the minimum wall reinforcement to cross the joints. This is disputed by some building officials. Research is needed to characterize the joint-opening and plastic-region behavior of walls without minimum wall steel, but with debonded length of vertical reinforcement in the ends of the walls to increase the strain distribution near the joints
Structural Systems	New cost-effective flooring system design that can be cast on long-line steel prestress beds	For a total precast concrete building, develop alternative sections to double tees and hollowcore. Develop floor system conducive to receiving integral plumbing, HVAC piping and/or electrical conduit.
	Effects of joint size and configuration in hollowcore systems subject to non- uniform loads	Building tolerances may require joints between slabs to increase in size and many layouts require splits creating non-standard joint configurations. The effects on load distribution need to be studied.
	Hybrid frame application to disproportionate collapse	Hybrid frames used for seismic resistance may have significant capacity for disproportionate collapse
Anchorage to Concrete	Effects of reinforcement in concrete anchorage breakout zones (**priority**)	Anchorage reinforcement is allowed in Chapter 17 of ACI 318, but the provisions are limited to direct transfer of shear and tension forces in the direction of the load and require development of the reinforcement on either side of the breakout surface. There is a need to develop resistance to side-face breakout using shear friction reinforcement with development achieved by longitudinal reinforcement inside the bends of ties or hairpins.
	Replacement of headed anchors with headed reinforcement (**priority**)	Considerations for the replacement of headed concrete anchors welded to embed plates with headed reinforcement.

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Anchorage to Concrete	Anchorage of standard hooks with transverse reinforcement inside hook bend **(priority)**	Currently we are limited to L_d for standard hooks controlled by breakout and crushing in the bend. These lengths will increase due to changes in ACI 318-19. There is no research to support reduced L_d values when transverse reinforcement is placed inside the bend to resist breakout cracking and to spread the crushing/bearing stresses from the bar tension.
	Reduction of volume change restraint forces in bearing pads	The N_u force used in bearing calculations can be calculated if the shear stiffness or slip stress of bearing pads is known.
	Consideration of anchorage where welded reinforcement is used together with headed anchor studs on plates	Embedded plates are often anchors with a combination of headed studs and reinforcement with standard hook or straight length for development, but there are no guidelines on how shear and tension loads are shared between them.
Wall Panels	Crack mitigation for insulated panels with continuous insulation **(high priority)**	Insulated wall panels with thin wythes tend to crack during detensioning. Develop alternative details, materials, or criteria to minimize cracking.
	Effect of reinforcement to improve edge lifting devices in thin panels	
Bridges and Girders	Maximum curvature of prestressed concrete I-girders permitted to be designed as straight girders **(priority)**	AASHTO LRFD permits a maximum curvature for steel I-girders below which the girders can be designed as straight girders. No similar provision exists for prestressed concrete girders. Perform a parametric study to determine the maximum curvature below which prestressed concrete girders can reasonably be designed as straight. Steel I-girders are currently permitted about 7/8" per 10 ft of length. For prestressed concrete I-girders even ¼" per 10 ft would be very helpful.

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Bridges and Girders	Interface shear at intersection of box beam web and bottom flange	Design optimization and production practices have resulted in conflicts about the adequacy of the interface between the web and flange of box beams. Research is needed to define shear friction parameters for "as-cast" interfaces where concrete placement is against green concrete rather than hardened concrete, such as those that are often encountered in precast box girder fabrication.
	Connection detailing	Girder to girder, girder to pier, and girder to abutment recommended detailing to improve durability. Deck to girder recommended detailing to simplify construction and improve durability.
3D Printing	Feasibility of pre-printed concrete components in plant	Precast producers have experience with handling, shipping, and erection. 3D printed concrete elements can have infinite shapes. Evaluate the feasibility of "pre-printed" (3D printed in a precast plant) elements and the type of precast components possible.
Handling and Erection	Productivity in the field	More efficient connections to replace welding to release product from the crane quicker to allow more pieces to be installed per day.
	Handling analysis tool to consider effects of lifting points and rotation of walls from horizontal to vertical.	Conventional lifting with 2- and 4-point picks does not always work with large panels or plant practice. Develop methodologies for other lifting configurations (3 or 5 points). Effects on panels during rotation may also not be considered. Evaluate handling stresses for both rolling block and fixed line lifting.
	Drone and/or laser scanning use for layout, clash detection and as-builts	Is a 3D point cloud produced by a drone's LiDAR survey accurate enough to use for layout for erection, clash detection in a BIM model and for as-builts.

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Materials	Super Air Meter testing for air-entrained precast concrete mixtures **(priority)**	A new test method employing a Super Air Meter (SAM) to evaluate the air-void system of fresh air-entrained concrete is gaining popularity, primarily for its speed of testing. A SAM maximum test value of 0.2 has been established based on the data, however, the vast majority of the mixtures evaluated are significantly different (lower slump, lower cementitious content, higher w/c ratio) than what is typically used in precast concrete. Preliminary testing of precast mixtures that pass hardened concrete air-void testing indicate SAM values significantly higher the 0.2. At least one state DOT has specified a SAM value of 0.2 for precast concrete, which will likely not be achievable. Further work must be done to evaluate the appropriate SAM value for precast concrete.
	Cement replacement in concrete mixes (**priority**)	Investigate alternative cementitious materials or carbon sequestration materials to reduce embodied carbon in precast elements. Note that most precast elements require high-early strength concrete mixtures to facilitate prestress release or stripping and handling.
	Delayed ettringite formation (DEF)	This research will evaluate the use of the “delta ettringite” testing method, which was developed as part of a PCI funded study in the late 1990’s. This proposed work will extend the scope to include measurements of concrete at later ages.
	100 year life for structure and repairs	Bridges and, eventually, parking structures will have requirements for a 100 year life. Materials and detailing need development to meet this requirement.
	Rate of tensile strength gain vs compressive strength gain in lightweight concrete	This information would contribute to knowledge on early age strength of anchorage in concrete

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Materials	Effects of elevated temperatures from fire on fiber reinforcement and FRP composites in precast concrete structural members	PCI 124 address fire resistance for steel reinforced precast concrete. Determine additional considerations for FRP reinforced precast concrete and for precast concrete mixes incorporating metallic and nonmetallic fibers.
Sustainability	Life-cycle costs for pretensioned concrete bridges (**priority**)	Limited information is available on life-cycle assessments for pretensioned concrete bridges. A comparison of life-cycle costs for pretensioned concrete bridges to other typical bridge systems, in particular simple- and short-span bridges is needed.
	Development of detailing to enhance resiliency in precast concrete structures	As compared to other construction materials, precast concrete has opportunities for superior resiliency for fires and natural events.
	Development of better tools to assess the positive effects of thermal mass on operational efficiency	
Architectural	Effect of moisture content on APC color	Architectural panel color can be judged at many different ages. What is the effect of moisture content?
	Post pour replacement techniques for brick, tile, and precast concrete medallions in APC	
	Form suction for stripping APC with projections and rustications	
	Bond of brick, tile, and precast concrete medallions in APC	
	Anchorage in thin panels constructed of UHPC **(high priority)**	
Operations	Trucking of precast concrete members from manufacturing plants to job sites	Managing specialty carriers and non-standard sized loads to arrive at the crane at the correct time + or – 5 minutes

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Operations	Handling of steel reinforcing, connection plates and inserts is the majority of work done in the manufacturing plant.	Eliminating or drastically reducing non-value added materials handling work in the manufacturing plants. Robotic application for highly repetitive low skilled work? Impact of autonomous delivery vehicles?
	Improved ergonomics in work tasks of production employees	Reduced bending and stooping, lifting of heavy and awkward loads.
	Inspection of product, both finished goods and work in process, by electronic means	Utilize cameras, lasers or specialized AR or VR equipment to measure product vs. conventional steel tape. Compare to CAD drawings or 3D models for tolerances.
	Understand ability of current processes to meet tolerances, especially dimensional tolerances that affect fit-up and subsequently productivity on job sites.	Capture all variances from standard dimensions, not just go/no go based on adherence to published tolerances. Use data captured to calculate and publish process capability analysis.
	Machine learning / artificial intelligence / robotics	A general investigation into how these things might benefit our industry