

## REQUEST FOR PROPOSALS

### Implementation of Ultra-High-Performance Concrete in Long-Span Precast Pretensioned Elements for Concrete Buildings and Bridges

#### Project:

Opportunities exist for advancing material technology for use in plant cast precast concrete. The plant production environment allows for material and process control that is not possible in a field cast environment. Ultra-high-performance concrete has been proven in other parts of the world, but has had little impact on the precast concrete industry in the US. This project is intended to advance material technology, structural design criteria, and testing procedures to allow implementation of the technology into existing and new markets.

#### Proposer Qualifications:

The proposing agency shall have demonstrated experience in concrete material technology and structural design. To assemble the required expertise, it shall be acceptable to submit as a partnership of several agencies. However, one agency shall be identified as the lead agency.

#### Proposal Requirements:

The Proposal shall include identification of the agency, the Principal Investigator, and all staff and partners that will provide work to the Project including complete contact information. It shall further include a description of related experience and available testing facilities. Detailed items to also be included in the proposal are described in the attached Research Project Statement.

The Project is defined in the Research Project Statement and is intended to be conducted in three phases. The Proposal shall include intended scope of work, schedule and cost for each phase. Each phase will require specific instruction from PCI to proceed and PCI will contractually reserve the right to terminate the project at any phase.

A sample PCI Research and Testing Agreement is attached and will be used as the contract form for the project. Any exceptions to terms of the agreement shall be noted in the proposal.

Proposals shall be submitted no later than **12:00pm Central Daylight Time on August 6, 2018**. The submittal shall be electronic in .pdf format. Submit to:

Roger Becker  
Vice President Technical Services  
Precast/Prestressed Concrete Institute  
200 W Adams Street  
Chicago, IL 60606  
rbecker@pci.org



**Proposal Review:**

Proposals received by the stated deadline will be reviewed by an Industry Advisory Committee composed of representatives from the Research and Development Council and the Concrete Materials Technology Committee. This group shall make a recommendation to the Research and Development Council for final project approval and proposer selection. PCI reserves the right to reject all proposals. It is anticipated that the final selection will be made by October 1, 2018.

**Payment Schedule:**

Payments to the successful agency shall be made according to the following schedule individually for each phase:

- 40% of lump sum cost upon notice to proceed with each phase
- 50% of lump sum cost upon delivery of draft deliverables
- 10% of lump sum cost upon acceptance of final deliverables

**Attachments:**

- Research Project Statement
- Sample PCI Research and Testing Agreement

**Research Project Statement**  
**Implementation of Ultra-High-Performance Concrete in Long-Span Precast Pretensioned Elements for Concrete Buildings and Bridges**

**Objectives:**

The primary objective of the project is to engage in an organized research and development program that culminates in the introduction of Ultra-High Performance Concrete (UHPC) for precast, pretensioned plant-produced products, particularly long span precast, pretensioned flexural components for bridges and floors of multistory office and/or parking structures. Such products would exhibit high strength, high toughness, high durability, weight reduction of up to 40 percent and much longer life than conventional concrete.

**Background:**

UHPC is a new class of concrete that uses particle packing theory and fiber reinforcement to achieve not only ultra-high compressive strength, but also high tensile strength and excellent toughness, represented by the area under the tensile load-elongation diagram. This material presents opportunities to optimize existing members made by precast, pretensioned concrete plants, create new products and markets, provide new connection designs, and make reinforced concrete products with unrivaled durability<sup>1</sup>.

Unfortunately, over two decades have passed since the introduction of UHPC in the US in 1994, and applications have been primarily limited to using UHPC in longitudinal joints between precast members. A lack of nationally developed and vetted design guidelines has resulted in reluctance by designers and owners to accept with confidence this exciting material. Such reluctance to use UHPC has been further compounded by the extremely high cost of pre-bagged proprietary materials.

There is no unique definition of UHPC. The Federal Highway Administration defines UHPC as concrete with at least 21.7 ksi compressive strength and 0.72 ksi tensile strength.<sup>2,3</sup> Fibers are used to increase tensile strength and enhance toughness. For precast pretensioned concrete members, compressive and tensile strength at prestress release, which normally occurs within 12 to 16 hours after concrete placement, are important. High pre-cracking tensile strength on the order of 1.5 ksi, post-cracking ultimate tensile strength on the order of 2.5 ksi, and considerable toughness would allow for more efficient sectional properties of precast, pretensioned products. Production costs are reduced as auxiliary rebar usage is minimized and production cycles are potentially shortened.

For PCI member plants, it is important to have a standard definition of UHPC for structural use in plant-precast pretensioned concrete members. Adequate guidelines for all processing stages,

including mix design, use of as many local ingredients as possible<sup>4</sup>, materials handling, batching, and quality control need to be developed and communicated to the precasters and their clients. Also, concrete mixing time, placement, control of “cold joints,” finishing, curing, product handling, storage, shipping and erection are steps that need to have new guidelines or ones adapted from conventional pretensioned concrete products, with recognition of new relatively thin member thicknesses and the potential of instability during handling.

The enhanced mechanical properties of ultra-high-performance concrete also provide opportunities for new precast, prestressed member geometries and systems that could open up new markets and expand existing ones. There are potential benefits in both bridge and building products. Thinner sections would permit reduced weight, easing transportation and erection. In buildings, elements with greater spans and/or shallower profiles could increase useable space by allowing for the elimination of columns and increased ceiling heights. In bridges, longer spans may allow elimination of piers and expanded use of precast concrete where steel girders are typically used. At this time in the US, only very few precast prestressed members have been made with UHPC, either directly by FHWA or by the states of Iowa and Virginia<sup>2</sup>, with significant subsidy from FHWA to encourage these states and others to begin to use this material in major elements.

One of the most impressive UHPC success stories is that of Dr. Voo in Malaysia<sup>5</sup>, as documented by Tadros and Voo in a recent *Aspire Magazine* article<sup>6</sup>. Dr. Voo and his company Dura have managed to build nearly 140 bridges, with spans as long as 120 m (360 ft). A visit by a delegation from PCI and a follow up visit to PCI by Dr. Voo have energized our technical committees and our desire to move from experimentation and hesitation to full-scale structural members. Our situation in the US is somewhat different from Malaysia, Europe, Australia and Japan where more progress has been made. In the US, our most dominant products are precast pretensioned, not segmental post-tensioned. As such, while taking advantage of progress abroad, we must develop, under the direction of PCI, products and processes that suit PCI’s economic structure. Labor in the US is relatively expensive and in short supply. In the US we favor large pieces to minimize handling and erection costs. We favor pretensioning due to its economy and superior behavior. This would require generation of relevant design guidelines, as well as materials related specifications.

## **Scope of work**

It is anticipated that this work will consist of the following tasks:

### **Task 1: UHPC Material Characterization and Production**

- a. Develop general parameters for a class of UHPC capable of producing large precast pretensioned concrete members with enhanced performance properties.
- b. Identify standardized test procedures to quantify concrete mechanical properties
- c. Determine material acceptance criteria for different applications
- d. Determine process control procedure requirements for reliable material

performance

### **Task 2: Sample Design Examples**

- a. Identify characteristic properties to be used in structural design of bridge and building flexural members. It is anticipated that the structural designer will require in the design documents minimum design compressive and tensile strengths at prestress release and at service. Also, it is anticipated that some measure of ductility or toughness, as well as stiffness (represented by a high modulus of elasticity) will be required.
- b. Develop fully worked out prototype bridge and office floor beam design examples. For example, fully design and detail an optimized precast pretensioned 250 ft span bridge beam for a 50 ft wide by 250 ft long bridge subjected to AASHTO loading. Another example is the main beam in a multistory office building (or parking structure) with a bay size of 60 feet by 60 feet and a total floor thickness of 18 inches. The examples should be selected to show immediate value of using UHPC in expanding the precast market. The purpose of the fully detailed examples would be to determine the research needs relative to structural design and all other aspects of production, handling, shipping and erection. Design equations and procedures may need to be verified with full scale testing of components. For example, web shear without varying contents of rebar, end zone cracking, interface shear with CIP topping/deck, prestress losses, deflections, etc.

### **Task 3: Structural Testing**

- a. Develop and execute test program on component level specimens to support development of national structural design criteria.
- b. Propose guidelines for inclusion in national design codes

### **Task 4: Technology Transfer**

Prepare quality control documents and design recommendations and other guides for use by precasters and designers. The documents are expected to be updated with the results of the demonstration projects in Task 5 when that task is completed.

### **Task 5: Demonstration Projects**

In cooperation with participating precasters and owners, design and build a sample bridge and a sample long span building floor. The intent of the demonstration is to encourage further commercial use of this new material and further point out additional research needs. The role of the research team in this task is coordination with previous tasks and monitoring of the activities in this

task. Its results will also be included in the package prepared in Task 4 for technology transfer.

### **Anticipated Deliverables**

It is anticipated that the research will be conducted in phases:

**Phase I: Tasks 1 and 2.** These tasks will result in the following deliverables:

1. Guidelines for UHPC Material Characterization and Production
2. A guide specification for use and testing of UHPC in precast/prestressed concrete applications.
3. Full design and detailing documents on design of at least one major bridge member and one major building member.

**Phase II: Tasks 3.** This task will result in full documentation required for changes in the codes to allow for use of UHPC. This will include, as a minimum, guidelines for vertical shear and interface shear design.

**Phase III: Tasks 4 and 5.** Technology Transfer and Demonstration. The demonstration task will likely involve selected state highway agencies and private (parking, office development) owners. The research team will document all aspects of the design, production and construction. The technology transfer deliverables will include the manuals developed in preceding tasks as well as educational webinars and in-house demonstration activities by interested precasters.

### **Schedule**

Phase I is expected to be completed simultaneously by materials experts and structural design experts in a period of 6 months.

Phase II testing will commence approximately 4 months after the end of Phase I and will be expected to last 14 months. It is expected that the work will be led by a principal investigator. It may be supported by co-principal investigators for each task.

Phase III is to be administered by PCI. The Technology Transfer task will be mostly based on the results of the first three tasks and is expected to last 12 months. The Technology Transfer package will be supplemented with information from Task 5 when available.



## References

- (1) Richard, P., and Cheyrezy, M.H., (1994). "Reactive Powder Concretes with High Ductility and 200-800 MPa Compressive Strength", *ACI*, SP-144(24), San Francisco, CA, pp: 507-518.
- (2) Russell, H. G. and Graybeal, B. A. Henry G. and Benjamin A., "Ultra-High Performance Concrete: A State-of-the-Art Report for the Bridge Community," Publication No. FHWA-HRT-13-060, National Technical Information Service, Springfield, VA 22161. 171 pp.
- (3) Graybeal, B., "Ultra-High Performance Concrete," *TechNote*, FHWA-HRT-11-038, Federal Highway Administration, McLean, VA, 2011.
- (4) Tadros, M. K. and Morcous, G., "Application of Ultra-High Performance Concrete to Bridge Girders," Nebraska Department of Roads (NDOR) Project Number P310, February 2009, Lincoln, NE 72 pp.
- (5) Voo, Y. L., Foster, S. J. and Hassan, M. F., "The Current State of Art of Ultra-High Performance Concrete Bridge Construction in Malaysia, Proceedings of the 12th International Conference on Concrete Engineering and Technology 2014 (CONCET 2014), 12-14 Aug, Selangor, Malaysia, pp. 95-102
- (6) Tadros, M. K., and Voo, Y. L., "Taking Ultra-High Performance Concrete (UHPC) to New Heights-The Malaysian Experience," *Aspire Magazine*, Summer 2016

## SAMPLE RESEARCH AND TESTING AGREEMENT

THIS RESEARCH AND TESTING AGREEMENT (the "Agreement"), effective as of the \_\_\_ day of \_\_\_\_\_, 20\_\_ (the "Effective Date"), is by and between Prestressed Concrete Institute, an Illinois not-for-profit corporation located at 200 West Adams Street, Suite 2100, Chicago, IL 60606 (hereinafter referred to as "PCI") and \_\_\_\_\_ (hereinafter referred to as "University").

In consideration of the premises, the mutual covenants herein contained and intending to be legally bound, the parties hereto agree as follows:

### Article 1 – Definitions

- 1.1 "Project" shall mean the performance of the scope work as defined in the research proposal entitled \_\_\_\_\_ and dated \_\_\_\_\_. The scope of work is incorporated herein by reference as set forth in full in attachment A.
- 1.2 "Agreement Term" is from the Effective Date through \_\_\_\_\_ [date].
- 1.3 "Principal Investigator" shall mean the individual(s) identified as such in the research proposal for Project, who is/are the University faculty and/or staff member(s) responsible for supervision and administration of the Project.
- 1.4 "Intellectual Property" shall mean individually and collectively all inventions, improvements, copyrights, patents, proprietary information or discoveries that are conceived or made (i) by University or (ii) jointly by PCI and University in performance of Project.
- 1.5 "Report" shall mean the periodic or final summary of work performed by University related to the Project.
- 1.6 "Material Breach" for the purpose of this Agreement shall mean any event, situation, condition, or lack of performance in accordance with the work plan defined in Attachment A which causes the Project to be significantly modified, delayed or cancelled.
- 1.7 "Completion of Work" shall mean the completion of goals, objectives and other measurements as defined in Attachments A.
- 1.8 "Acceptance of Final Paper" shall mean the acceptance by PCI of the final deliverables defined in Attachment A at its sole discretion. The intent shall be a judgment of the quality of the deliverable and not a judgment on the results of the research.

## **Article 2 – Conduct of Project**

- 2.1 University shall use reasonable efforts to commence the Project promptly after the Effective Date.
- 2.2 In the event that the Principal Investigator becomes unable or unwilling to continue Project, and a mutually acceptable substitution is not available, University and/or PCI shall have the option to terminate said Project, subject to the provisions of Article 8, by giving written notice to the other party of such termination.
- 2.3 PCI shall promptly provide University with such information or documents of whatever form or nature, or undertake such actions, as University may reasonably require in order to conduct the Project.

## **Article 3 - Reports and Conferences**

- 3.1 Project reports will be provided by University to PCI as set forth in the Project proposal and a final report will be submitted by University at the conclusion of the Agreement Term or earlier termination of this Agreement.
- 3.2 PCI shall have the right to reproduce, publish, and disseminate any written reports or deliverables delivered to PCI by the University pursuant to this Agreement. Ownership and copyright for such reports or other materials shall vest in PCI.
- 3.3 During the Agreement Term, representatives of University will meet with representatives of PCI at such reasonable times and places as set forth in the Project proposal to discuss the progress and results of, as well as ongoing plans or agreed upon changes in the Project.

## **Article 4 – Compensation and Expenses**

- 4.1 It is agreed to and understood by the parties hereto that except as may be otherwise agreed by the parties in writing, total costs to PCI for the Project hereunder shall not exceed the sum of \_\_\_\_\_ (\$\_\_\_\_\_).  
Payment to University shall be made by PCI according to the following schedule:

*[as defined in the project RFP]*

- 4.2 University shall retain title to all equipment, materials, and supplies purchased and/or fabricated by it with funds provided by PCI under this Agreement unless otherwise stated in Attachment A.

## **Article 5 – Publicity and Use of Name**

- 5.1 Neither party shall be allowed to use the name of the other party or its representatives in any advertising regarding the Project without the prior written consent of the other party. The University shall identify PCI as the sponsor in any publicity, advertising or news release regarding the Project. PCI shall be allowed to use the name of the University and the Principal Investigator for announcements of the project and for Project updates to the PCI membership and such announcements and updates shall not be considered advertising.

## **Article 6 - Publications**

- 6.1 University may catalog and place reports of the Project in the University library and may issue publications based on the Project. The research results not proprietary to PCI, as agreed by PCI, may be used in University research and education programs. University shall provide PCI the opportunity to review any report or publication and will, upon the request of PCI, withhold publication for up to 90 days.

## **Article 7 – Intellectual Property**

- 7.1 Title to all Intellectual Property developed in the course of performance of the Project, whether or not protectable by patent, trade secret, or copyright, shall reside in the party whose personnel conceived the subject matter and diligently pursued reducing the subject matter to practice, and such party may perfect legal protection therein in its own name and at its own expense. Jointly made or generated Intellectual Property shall be jointly owned by the parties unless otherwise agreed in writing.

## **Article 8 – Agreement Term and Termination**

- 8.1 This Agreement shall become effective upon the Effective Date and shall continue in effect for the Agreement Term unless sooner terminated in accordance with the provisions of this Article. The parties hereto may, however, extend the Agreement Term for additional periods as desired under mutually agreeable terms and conditions which the parties shall reduce to writing and sign.
- 8.2 Either party may terminate this Agreement upon thirty (30) days prior written notice in the event of a Material Breach by the other party of any term or provision hereof, provided such breach remains uncured at the end of said thirty (30) day period. Such notice of a breach shall include a reasonable description of the facts surrounding the alleged breach and a proposed course of action to cure said breach, if applicable.
- 8.3 PCI shall pay the University any costs which have accrued or been encumbered up to the actual date of termination under this Article and shall not be relieved of the obligation to

pay such costs because of termination under this Article.

- 8.4 Termination of this Agreement by either party for any reason shall not affect the rights and obligations of the parties accrued prior to the effective date of termination of this Agreement.
- 8.5 No termination or expiration of this Agreement, however effectuated, shall release the parties hereto from their respective rights and obligations under Articles 3, 5, 6, 7, 8, 9, 10, 12, 13, 16, and 17, which such Articles shall survive in their entirety any termination or expiration of this Agreement.

#### **Article 9 - Arbitration**

- 9.1 In the event of any conflict or claim arising out of or relating to any provision of this Agreement or breach thereof, the parties shall make a good faith effort to resolve such conflict amicably between themselves, and if thereby failing, resolution by submission to mediation under the Construction Industry Mediation Rules of the American Arbitration Association, and if thereby failing, resolution by arbitration under the Construction Industry Arbitration Rules of the American Arbitration Association. The location of any mediation or arbitration shall be within the metropolitan area of Chicago, Illinois.

#### **Article 10 - Disclaimer of Warranties**

- 10.1 University disclaims any and all warranties, both express and implied, with respect to the services to be performed hereunder and any deliverables resulting therefrom, including their condition, conformity to any representation or description, the existence of any latent or patent defects therein, and their merchantability or fitness for a particular use or purpose.

#### **Article 11 - Insurance**

- 11.1 University shall carry the following insurance coverage with companies acceptable to PCI.
- 11.1.1 Commercial General Liability, including Contractual Liability and Completed Operations/Products Liability coverage, at the minimum limit of \$2,000,000 per project/ per occurrence (depending on degree of risk, other limits may be appropriate) and \$5,000,000 aggregate;
  - 11.1.2 Automobile Liability at \$1,000,000 each accident.
  - 11.1.3 Workers' Compensation at statutory limits and Employer's Liability coverage at a minimum limit of \$1,000,000;
- 11.2 Prior to commencement of the Project pursuant to this Agreement, University shall furnish PCI with proof of insurance, satisfactory to PCI in its sole discretion, evidenced by duly authenticated certificates of insurance, which certificates shall show the

insurance type, amount, class of operations covered, effective dates, and dates of expiration of policies.

## **Article 12 – Independent Contractor**

12.1 In the conduct of the Project hereunder, University and PCI are and shall remain independent contractors and nothing herein shall be construed to create a partnership, agency or joint venture relationship between the parties. Neither party is authorized or empowered to act as agent for the other for any purpose and shall not on behalf of the other enter into any contract, warranty or representation as to any matter. Neither party shall be bound by the acts or conduct of the other. Each party shall be responsible for wages, hours, and conditions of employment of its personnel during the term of, and under, this Agreement.

## **Article 13 - Governing Law**

13.1 This Agreement shall be governed by and construed in accordance with the laws of the State of Illinois.

## **Article 14 - Notices, Invoices, and Payments**

14.1 Notices, invoices, communications and payments hereunder shall be deemed made if given in writing and addressed to the party to receive such notice, invoice, communication or payment at the address given below, or such other address as may hereafter be designated by notice in writing:

If to Sponsor: Roger Becker  
Precast/Prestressed Concrete Institute  
200 West Adams St.  
Suite 2100  
Chicago, IL 60606

If to University:

## **Article 15 - Force Majeure**

15.1 In the event that either party is unable, wholly or in part, to carry out its obligations under this Agreement by reason of acts of God or public enemy, wars, insurrections, civil disturbances, epidemics, labor disputes, failure of government approval, accidents, failure of utilities, material shortages, fires, storms, floods and any other causes, whether of the kind enumerated herein or otherwise, not within the control of the party unable to

perform, then the obligations of this Agreement shall be suspended during the reasonable continuance of any inability so caused.

**Article 16 – Non-Discrimination**

16.1 University and PCI shall not discriminate against any employee or applicant for employment because of race, color, sex, sexual preference, age, religion, national origin, disability, or because he or she is a disabled veteran or veteran of the Vietnam Era.

**Article 17 - Assignment**

17.1 This Agreement shall not be assigned by either party without the prior written consent of the other party hereto. This Agreement shall be binding upon and inure to the benefit of the respective successors and permitted assigns of the parties.

**Article 18 - Agreement Modification**

18.1 Any agreement to change the terms of this Agreement in any way shall be valid only if the change is made in writing and signed by a duly authorized representative of each party hereto.

**Article 19 - Entire Agreement**

19.1 This Agreement constitutes and expresses the entire agreement of the parties hereto with reference to the subject matter hereof, with all prior promises, undertakings, representations, agreements, understandings and arrangements relative thereto having been herein merged into this Agreement

IN WITNESS WHEREOF the parties have caused this Agreement to be executed, each by its duly authorized representative, to be effective as of the Effective Date defined herein.

**UNIVERSITY:**

**PRESTRESSED CONCRETE INSTITUTE:**

By: \_\_\_\_\_

By: \_\_\_\_\_

Title: \_\_\_\_\_

Title: \_\_\_\_\_

Date: \_\_\_\_\_

Date: \_\_\_\_\_