**Request for Research Proposal**

**RFRP-19-001**

**Evaluation of Concrete Pile to Footing or Cap Connections**

This request is open to Florida universities with an executed Master University Agreement on file with the Florida Department of Transportation.

Details of the Services are described in Exhibit “A”, Scope of Services, attached.

The basis form of Agreement shall be a task work order issued under the Master University Agreement by the Research Center.

The maximum amount of funding available is $300,000.00 and the anticipated timeframe for the project is 36 months.

**Proposal Format Instructions:**

1. The University is encouraged to limit the proposal to no more than 30 pages. The cover page should contain the contact information for an Administrative contact and the Principal Investigator.
2. Provide an Executive Summary, written in non-technical language describing capabilities and approaches for accomplishing the services.

III. Provide a Management Plan which explains the functions and responsibilities of each key person and their experience developing and/or conducting research to support evaluating concrete pile to footing or cap connections. The team must include at least one member with practical experience in the design and plans production of major bridge substructures.

IV. Provide the names and resumes of key personnel of the Proposer’s team.

V. Provide a Technical Plan which demonstrates an understanding of the scope, detailed approach to accomplish each of the assigned tasks as required by the scope of service, to include specific deliverables for each task. List any special programs, software, or equipment that will be utilized to perform the work.

VI. Provide a Work Plan with estimated project hours by skill classification.

**Price Format Instructions:**

I. The Price information shall be submitted separately on the form provided and a detailed budget to support the lump sum amounts identified for each deliverable. Indirect cost is limited to 10%.

**Proposal Evaluation:**

A Technical Review Committee will review and evaluate each proposal submitted. The Committee will evaluate each technical proposal and assign a Technical Score based on the criteria identified below.

Executive Summary 10 points

Management Plan 30 points

Technical Plan 40 points

Work Plan 20 points

**Price Evaluation**

The Research Center will view the Price information and assign points based on price evaluation formula. The criteria for price evaluation shall be based upon the following formula:

(Low Price/Proposer’s Price) x Price Points = Proposer’s Awarded Points

Price 10 points

**Technical Questions are due by 3:00 PM on October 31, 2018**

Technical questions should be submitted to [patti.brannon@dot.state.fl.us](mailto:patti.brannon@dot.state.fl.us) with the subject line

RFRP-19-001 Technical Questions

**PLEASE EMAIL PROPOSALS TO:**

Patti Brannon at [patti.brannon@dot.state.fl.us](mailto:patti.brannon@dot.state.fl.us)

Include in the subject line the following information: RFRP-19-001 Evaluation of Concrete Pile to Footing or Cap Connections

**PROPOSAL ARE DUE BY 5:00 PM ON DECEMBER 19, 2018.** Proposals received after this date and time will not be accepted.

The Research Center will notify all proposers of the final decision on January 16, 2019.

**Special Notes:**

**Proposal will be rejected if more than one proposal is received from a University.**

**The Research Center intends to award the contract to the responsible and responsive proposer whose proposal is determined to be the most advantageous to the Department.**

Any questions related to this request should be directed to Patti Brannon at [patti.brannon@dot.state.fl.us](mailto:patti.brannon@dot.state.fl.us) or (850) 414-4616.

Exhibit A – Scope of Service

Evaluation of Concrete Pile to Footing or Cap Connections

**Background Statement**

The Department currently assumes a pinned connection for piles embedded 1-foot within a concrete footing or cap and a fixed connection for piles embedded 4 feet within a concrete footing or cap, as specified in the FDOT Structures Design Guidelines [1]. This assumption under certain circumstances could prove unconservative, and previous research has indicated the assumption is unrealistic [2].

For bridge designs with a fixed connection between the superstructure and substructure, boundary condition assumptions are critical. Positive and negative moment demands in the superstructure depend on the substructure stiffness and the level of fixity provided. The overall level of fixity provided by the substructure is affected by the local connection between the pile and pile cap or footing. Better understanding of the connection between prestressed concrete piles and pile footings or pile caps is needed so that future designs and design reviews can be adequately performed. Similarly, framed straddle piers can be sensitive to assumed pile-to-footing fixity assumptions especially in cases where the straddle cap is long and post-tensioned (i.e. subject to significant elastic shortening and long-term creep).

Castilla et al. [2] conclude that the rule of thumb which indicates that a 1-foot pile embedment produces a pinned connection and a 4-foot pile embedment produces a fixed connection is unrealistic. An embedment equal to twice the pile diameter, 2.33 feet in the Castilla et al. [2] work, produces a condition approximating full fixity while a 1-foot embedment develops 64% to 83% of the moments for a 4-foot embedment length. Rollins and Stenlund [3] confirmed that a pile embedment equal to twice the pile diameter, 2 feet in this case, performed successfully. Lesser embedment is required for the same performance if a reinforcing cage is placed in the steel pipe pile.

Research completed by Castilla et al. [2] and Rollins and Stenlund [3] focused on steel piles embedded in cast-in-place concrete. While the work is potentially applicable to prestressed concrete piles, other research exists which is specific to prestressed concrete piles. Harries and Petrou [4] investigated 18-inch square prestressed piles embedded 18 inches and 24 inches into a cast-in-place cap. The embedments investigated correspond to 1 and 1.5 times the pile width, respectively. Harries and Petrou [4] concluded that an embedment equal to the width of the pile can conservatively develop the flexural capacity of the pile. The flexural capacity of the pile may not be fully available with that length of embedment, as the capacity depends on the strand development length. However, since maximum moment demand generally does not occur at the pile to pile cap interface, full flexural capacity may be unnecessary.

Larosche et al. [5] also investigated 18-inch square prestressed piles but concluded that more embedment length is required. Larosche et al. [5] recommend an embedment depth equal to 1.3 times the pile width. They also present a detail for a 2-inch embedment and dowel bars which produces a pinned connection. Harries and Petrou [4] and Larosche et al. [5] conclude that different embedment lengths are required; 1 and 1.3 times the pile width, respectively. One difference in the work performed by the two research groups is that, in the testing performed by Harries and Petrou [4], a constant compressive load was applied to the test pile. Larosche et al. [5] applied a variable axial load to the test pile which oscillated into both compression and tension.

Previously completed research indicates that the embedment lengths required by the FDOT Structures Design Guidelines [1] to achieve a pinned or fixed connection may not be accurate. For an 18-inch prestressed concrete pile, the recommended embedment length based on previously noted reports would vary between 18 inches and 3 feet and changes for different pile widths. In contrast, the Structures Design Guidelines [1] require 4 feet of embedment for a fully fixed connection which is constant for all pile sizes between 12 and 30 inches. The Structures Design Guidelines indicate an embedment of 1-foot produces a pinned connection, while Castilla et al. [2] reports that significant moment capacity can be developed with only 1-foot of embedment and Larosche et al. [5] recommends an embedment of 2 inches for a pinned connection. Among previously completed research, the embedment length in a cast-in-place footing or cap which is required to achieve full fixity of a pile is somewhat inconsistent. Two reports indicate an embedment of 2 times the pile width is required, one report indicates one times the pile width is required, and another indicates 1.3 times the pile width is required.

Better understanding of the connection between prestressed concrete piles and cast-in-place footings and pile caps is needed to assure designs are completed correctly and conservatively. With the current state of available literature, further investigation is appropriate to define the required pile embedment lengths for both a fixed and pinned connection to cast-in-place footings and pile caps. With better understanding, boundary conditions can be more accurately estimated for bridges for which boundary assumptions are critical.

**Project Objectives**

The primary benefit of this project is to better understand the pile to cap or footing connection such that the Department can provide better design guidance along with more informed design reviews. Understanding the level of fixity provided within that connection will allow designers to provide a more optimized and robust design. This research project is anticipated to only address the connection between a prestressed concrete pile and cast-in-place footing or pile cap. The primary concern is to determine the required pile embedment to achieve a fully fixed or pinned moment connection. A secondary concern is estimation of the level of partial fixity for embedment lengths between a pinned and fully fixed embedment length. A third objective is to develop reinforcement details which decrease the required embedment length to develop fixity with a plain pile. The research will consist of a synthesis, analytical investigation and experimental testing.

To understand the current state of knowledge and practice for pile to cap or footing connections, it is expected that an extensive literature review will be performed. Previously completed research should be reviewed and summarized and should be used to plan appropriate analytical and experimental testing. State of practice should also be summarized with information collected from FDOT and other state DOT guidance and pile embedment details. Design issues related to pile fixity should be addressed to ensure analytical and experimental testing appropriately addresses cases where fixity is critical. Typical pile loading scenarios for critical cases should be examined. Consider practical designs which may include tensile and compressive axial loading along with moment.

Computational analysis should be completed as part of the research investigation. The research team shall predict the required embedment depths for a fixed and pinned connection before plans for experimental testing are developed. Computational analysis can also be used to develop equations to predict levels of fixity for incremental embedment lengths between those required for a pinned and fully fixed connection. Any conclusions shall be based on analyses which are properly validated with experimental testing results. The computational analysis shall include a range of pile sizes, minimum footing and cap sizes, reinforcing schemes and concrete strengths commonly used by FDOT. Loading patterns and magnitudes shall be typical of FDOT bridges. Identify structure types (e.g. post-tensioned framed straddle piers, post-tensioned framed structures with fixed pier tables) where assumed boundary conditions are more critical, conduct a sensitivity assessment that varies pile-to-cap fixity assumptions. Analysis shall be based on and build upon research previously completed. Coordination with the FDOT Project Manager (PM) shall take place for selection of the analysis methods and parameters to be evaluated.

Once the initial computational analysis is complete, levels of fixity for various pile embedment depths shall be evaluated by experimental testing. Experimental testing conducted at the FDOT Structures Research Center (SRC) will also serve to validate computational analysis. Conceptually develop testing plans based on computational analysis and literature review, building upon research previously completed. Test specimens shall be selected from the preliminary results of the computational analysis. Provide detailed drawings depicting the proposed test specimens and their installation in the test frame. The test setup and loading configurations shall be designed to be within the constraints of the FDOT SRC capabilities. Provide specifications as required for successful test specimen construction. Develop test procedures including load magnitudes, patterns and loading procedures that are typical for FDOT bridges. Provide and deliver materials required for test specimen(s) assembly to the FDOT SRC. Any required prestressed concrete components shall be fabricated at a FDOT approved production facility and delivered to the FDOT SRC.

Conceptually and analytically evaluate results of the experimental testing and use those results to validate the computational analysis. Use the computational analysis and experimental testing results to develop equation(s) which predict the level of moment transfer for various embedment lengths and reinforcement layouts. Develop design guidance, including visual aids, based on conclusions of the research effort. Refine sensitivity assessments of critical structure types mentioned above based on experimental test data of measured fixity ranges. Establish design methodologies that envelope worst case loads.

**Anticipated Tasks**

Project Kickoff Teleconference

The principal investigator will schedule a kickoff meeting that shall be held within the first 30 days of task work order execution. The kickoff meeting will consist of a webinar at least 30 minutes in length. The purpose of the meeting is to review the tasks, deliverables, deployment plan, timeline, and expected/anticipated project outcomes and their potential for implementation and benefits. The principal investigator shall prepare a presentation following the template provided at <http://www.fdot.gov/research/Program_Information/Research.Performance/kickoff.meeting.pdf>

The project manager, principal investigator, and research performance coordinator shall attend. Other parties may be invited, if appropriate.

1. Literature Review
2. Matrix of Parameters to Study
3. Preliminary Computational Analysis Results
4. Test Procedures and Instrumentation Plans
5. Construction Plans and Specifications for Experimental Test Specimens
6. Experimental Test Specimen Material Delivered
7. Experimental Test Results and Conclusions
8. Demolition and Removal of Test Specimens
9. Final Computational Analysis Results
10. Design Guidance and Visual Aids (Design Details)

Task 11a - Draft Final Report

Ninety (90) days prior to the end date of the task work order, the university will submit a draft final report to [research.center@dot.state.fl.us](mailto:research.center@dot.state.fl.us)

The draft final report will contain *(insert description of information the report will contain)*.

The draft final and final reports must follow the Guidelines for University Presentation and Publication of Research available at <http://www.fdot.gov/research/docs/T2/University.Guidelines.2016.pdf>

The report must be well-written and edited for technical accuracy, grammar, clarity, organization, and format.

Task 11b - Close-out Teleconference

Thirty (30) days prior to the end date of the task work order, the principal investigator will schedule a closeout teleconference. The principal investigator shall prepare a Powerpoint presentation following the template provided at <http://www.fdot.gov/research/Program_Information/Research.Performance/closeout.meeting.reqs.pdf>

At a minimum, the principal investigator, project manager, and research performance coordinator shall attend. The purpose of the meeting is to review project performance, the deployment plan, and next steps.

Task 12 - Final Report

Upon Department approval of the draft final report, the university will submit the Final Report in PDF and Word formats electronically to the Research Center at [research.center@dot.state.fl.us](mailto:research.center@dot.state.fl.us) The Final Report is due by the end date of the task work order.

# **Bibliography**

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| [1] | Florida Department of Transportation, FDOT Structures Manual, 2018. |
| [2] | F. Castilla, P. Martin and J. Link, "Fixity of Members Embedded in Concrete," US Army Corps of Engineers, Champaign, 1984. |
| [3] | K. M. Rollins and T. E. Stenlund, "Laterally Loaded Pile Cap Connections," Brigham Young University, Provo, 2008. |
| [4] | K. A. Harries and M. F. Petrou, "Behavior of Precast, Prestressed Concrete Pile to Cast-in-Place Pile Cap Connections," *PCI Journal,* Vols. July-August, pp. 82-92, 2001. |
| [5] | A. Larosche, P. Ziehl, M. K. ElBatanouny and J. Caicedo, "Plain Pile Embedment for Exterior Bent Cap Connections in Seismic Regions," *Journal of Bridge Engineering,* 2013. |

**Deliverables Schedule**

*Note: this document will be used by the Research Center to monitor principal investigator performance and activity on the project. The PI should give careful consideration to the time needed to complete a task(s) and deliverable(s) against current workload. Failure to submit deliverables in a timely manner may result in cancelation of the task work order.*

Remember to include kickoff teleconference, submittal of draft final report, closeout teleconference and final report. The Research Center must at a minimum receive a deliverable every 6 months on a project. Failure to submit deliverables in a timely manner may result in cancelation of the task work order. Progress Reports are not considered deliverables.

**For planning purposes February 2019 should be used as the anticipated start date for this project.**

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| Deliverable # / Description of Deliverable as provided in the scope (included associated task #) | Anticipated Date of Deliverable Submittal (month/year) | TO BE COMPLETED BY RESEARCH CENTER (performance monitoring) |
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RFRP-19-001

Evaluation of Concrete Pile to Footing or Cap Connections

PRICE PROPOSAL

Task 1 Deliverable (Lump Sum Amount) $

Task 2 Deliverable (Lump Sum Amount) $

Task 3 Deliverable (Lump Sum Amount) $

Task 4 Deliverable (Lump Sum Amount) $

Task 5 Deliverable (Lump Sum Amount) $

Task 6 Deliverable (Lump Sum Amount) $

Task 7 Deliverable (Lump Sum Amount) $

Task 8 Deliverable (Lump Sum Amount) $

Task 9 Deliverable (Lump Sum Amount) $

Task 10 Deliverable (Lump Sum Amount) $

Task 11a and 11b Deliverable (Lump Sum Amount) $

Task 12 Deliverable (Lump Sum Amount) $

Proposer must attach a detailed budget to support the lump sum amount identified per task. If applicable, the following information must be included.

**Use of Subcontractor(s)**

If a subcontractor is to work on the project, describe the work the subcontractor will perform. A scope of work and budget must be provided for the subcontractor.

**Use of Graduate Student(s) and other Research Assistants**

Describe the work any student(s) will perform.

**Equipment**

Florida Administrative Code states “for statewide financial reporting purposes, all tangible personal property with a value or cost of $1,000 or more and having a projected useful life of one year or more must be capitalized. Any hardback book with a value or cost of $25 or more and having a useful life of one year or more that is circulated to students or the general public, and any hardback book with a value or cost of $250 or more that is not circulated must be capitalized. A review of the items on the Exception Property should be performed to ensure items to not fall within this category.

*Universities must adhere to the Department’s $1,000 threshold for equipment or items of lesser value appearing on the Exception Property listing. The university must provide a copy of the purchase invoice/property description/serial number and date of receipt for the equipment with the applicable task invoice.*

A description of the equipment to be purchased must be included with a copy of the quotes obtained. Justification of specific requirements for the project and why the equipment should be purchased instead of leasing (leasing of equipment is preferred) is required for all equipment.

**Expenses**

Describe any expense items to be purchased, if applicable.

**Travel**

***Standard Research Center policy is that travel to conferences is not an allowable expenditure*.**

Describe travel that will take place, including justification of the need for travel, if applicable. Include the traveler’s name/position, location(s), purpose and duration.

*If travel is budgeted, the following text must appear, as worded:*

All travel shall be in accordance with Section 112.061, Florida Statutes. Bills for travel expenses specifically authorized in the agreement shall be submitted using the Department’s Travel Form No. 300-000-06, unless the university provides proof of the Department of Financial Services approval to use an alternate travel form. The Department shall not compensate the University for lodging/hotel in excess of $150.00 per day (excluding taxes and fees).

The maximum amount of travel is limited to $(insert amount). The maximum amount of indirect cost on travel is limited to $(insert amount).