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Extended Abstract (no paper submission)

# Large Bars Spliced in UHPC for PBES Substructures

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Bridges
Connections

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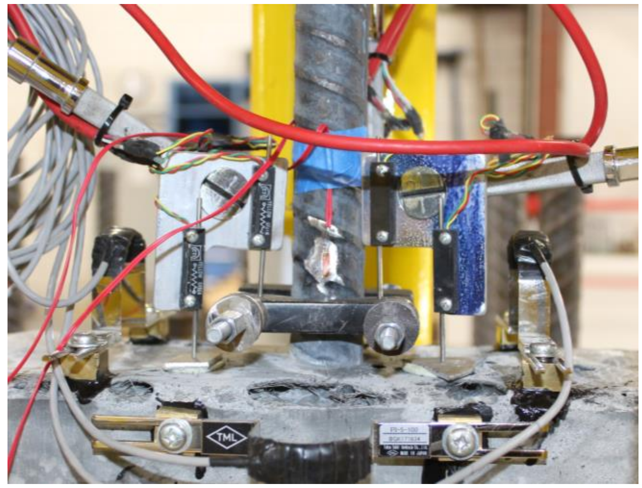
## Extended Abstract

Construction time savings can be realized through replacement of cast-in-place substructure columns and/or piers with prefabricated bridge elements and systems (PBES). Typical cast-in-place substructure construction requires forming, placing steel and pouring concrete at the construction site. Further work cannot progress until the concrete reaches a specified strength. Use of precast elements can decrease the extent of work required at the site and potentially reduce required concrete curing time.

Ultra-high performance concrete (UHPC) can be used as a joining material for PBES. UHPC has high early strength, requires less development or splice length than conventional concrete and has been used previously for accelerated construction projects. UHPC also has a discontinuous pore structure that reduces liquid ingress, significantly enhancing durability compared to conventional concrete. Although UHPC has been researched extensively, previous research for reinforcing bar splice and development lengths have focused on #9 and smaller diameter bars. Typically, larger diameter bars are used for substructures. Some research has been conducted for splice length of #11 bars, but the number of tests is limited.

The research project discussed in this presentation addresses single bar splice capacity for a range of variables, including bar size, splice length and concrete cover. The bar sizes considered are #8, #9, #10 and #11 bars. The considered bar sizes are typical for substructure construction and include the maximum size permitted by the Florida Department of Transportation Structures Detailing Manual for footings, pier columns, piers and bent caps.

The experimental loading apparatus consists of a hydraulic cylinder and load cell in line with a rebar chuck, set on a steel support which bridges the UHPC splice. Each test bar was loaded in direct tension at a load rate of 0.0033 inches per second until strain hardening, with an accelerated rate after strain hardening. Instrumentation consists of deflection, strain and crack gages. Photos below show the loading apparatus and instrumentation.



To date, eighty direct tension pull-out tests have been completed on bars spliced in UHPC, with various bar sizes, clear cover, and embedment/splice lengths. Four different bar sizes have been tested with clear covers of 1.75 and 3.75 inches and splices with bars in contact and spaced 6-inches apart, center-to-center. A commercially available UHPC with 2% steel fibers by volume was used. The targeted strength for testing was between 10 and 14 ksi, which usually occurred within 2-3 days of casting. The range of tested splice and embedment lengths are listed below.

| Bar Size | Clear Cover (in.) | Embedment (in bar diameters) | Splice (in bar diameters) |
|---|---|---|---|
| #8 | 3.75 | 8 | 6 |
| | 1.75 | 8 | 6 |
| #9 | 3.75 | 8 | 6 |
| | 1.75 | 8, 10 | 6, 7.5 |
| #10 | 3.75 | 8 | 6 |
| | 1.75 | 10, 12 | 8.5, 10 |
| #11 | 3.75 | 10, 11 | 8, 10 |
| | 1.75 | 12, 13 | 10, 11 |

Preliminary results will be presented in this session for the tests completed to date. Physical testing is still ongoing with various bar spacings, embedment lengths, and fiber orientation. Upon completion, the planned outcome of this research project is recommendations for required embedment and splice lengths for large diameter bars spliced in UHPC.