

**Office of Research and Implementation**

**FFY 2022 Request for Proposals**

Research Problem Statement Title:

**Innovative Multi-Hazard Resistant Bridge Columns for Accelerated Bridge Construction**

Problem Statement:

The Federal Highway Administration (FHWA) and state departments of transportation (DOTs) in the U.S. are actively promoting accelerated bridge construction (ABC) to minimize construction costs and time and to enhance work-zone safety. While several techniques are available to accelerate bridge superstructures, limited techniques are available to accelerate bridge substructures. Precast columns that can be rapidly installed on site are usually an excellent candidate for economic ABC. However, the weights of precast columns need to be minimized for transportation and handling. Hollow core (HC) sections have been used in Europe, Japan, and New Zealand to reduce the weights of tall precast concrete columns. HC precast concrete cross sections offer high strength-to-weight ratios and high stiffness-to-weight ratios, which are desirable in construction and can save a significant amount of material compared to solid columns. Studies have shown that HC columns reinforced using two coaxial layers of reinforcement linked by a large number of cross ties have ductile behavior under seismic loads. However, such details are time consuming and labor intensive, resulting in higher construction costs. HC concrete columns constructed using a single layer of flexural steel display brittle behavior under seismic loads due to a lack of confinement of the inner concrete surface leading to early spalling and low-cycle fatigue rupture of the flexural reinforcement. This proposal focuses on accelerating substructure construction using an innovative multi-hazard resistant bridge column. The column consists of a concrete core sandwiched between an outer fiber-reinforced polymer (FRP) tube and an inner steel tube. Both tubes will act as stay-in-place forms and also confine the concrete core.

Proposed Research:

The proposed project includes static cyclic testing of half-scale columns, static cyclic testing of small-scale connection elements, and a parametric finite element analysis. The large-scale column tests will investigate the effects of concrete core thickness, concrete core material (SCC and UHPC), and column aspect ratio (slender, intermediate, and squat). The small-scale testing includes investigating the column-footing and column-girder connections. The finite element analysis will investigate the effects of different parameters on embedment length and strength of the columns.

Suggested Tasks (to include but not limited to):

1. Design and construct six (6) large-scale columns having different aspect ratios, steel tube thickness, FRP thickness, and concrete core material type (SCC or UHPC).

2. Test columns under lateral cyclic load and constant axial load.

3. Design and construct small-scale column-footing and column-girder connections.

4. Test small scale connections under lateral cyclic load and constant axial load.

5. Develop finite element models to investigate the effects of different parameters on embedment length and strength of the columns.

6. Develop design procedures and recommendations for foundation embedment length, steel, concrete, and FRP wall thicknesses, concrete type (SCC and UHPC), and nominal flexural and shear strength of the composite columns.

7. Prepare monthly, annual, and final reports.

Implementation:

Bridge construction and safety

Benefits:

The expected benefits include a system that has several advantages over existing construction methods, including accelerated construction time, lower construction costs, lower life-cycle costs, and reduced environmental impact by using materials more effectively. Furthermore, the double skin column system will have improved resistance to earthquakes, vehicle impact, and blast loads.

Deliverables:

All projects require the submission of the following reports:

* Monthly Progress Reports
* Multi-Year Projects require a Year-end Annual Report
* Copies of the project Draft Final Report in Microsoft Word and ADA accessible Adobe Acrobat pdf electronic formats
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The Year-end Annual Report, Draft Final Report, Final Report and Color Article should be submitted to satisfy all federal and state requirements pertaining to the accessibility of documents including but not limited to:

* Oklahoma State Statute 62 § 41.5e and the Americans with Disability Act (ADA) of 1990, 42 USC 12.01 et seq.

The PI must also participate in the following project meetings:

* New project initiation meeting
* Semi-annual project meeting
* Close-out project meeting
* Continuing project meeting
* Estimated completion time two years.

Existing Research found in separate attached file.