

UTC Project Information	
Project Title	MPC-511 – Mechanical Bar Splices for Accelerated Bridge Construction of Columns
University	South Dakota State University
Principal Investigator	Mostafa Tazarv, PhD Nadim Wehbe, PhD, PE
PI Contact Information	<p>Mostafa Tazarv, PhD Assistant Professor Department of Civil and Env. Eng. South Dakota State University Phone: (605) 688-6526 Email: mostafa.tazarv@sdstate.edu</p> <p>Nadim Wehbe, PhD, PE Professor Department of Civil and Env. Eng. South Dakota State University Phone: (605) 688-4291 Email: nadim.wehbe@sdstate.edu</p>
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Project Duration	September 30, 2013 to September 30, 2018
Brief Description of Research Project	<p>Accelerated bridge construction (ABC) is a new paradigm in the USA mainly to expedite construction using new techniques, advanced planning, and novel detailing. ABC heavily relies on prefabricated bridge elements and systems. Pilot studies indicated that the application of precast columns in the USA is limited due to uncertainties related to the performance of precast column connections (Marsh et al., 2011; Kapur et al., 2013).</p> <p>One method to connect precast columns to adjoining members is through the use of mechanical bar splices commonly referred to as couplers. Even though current codes prohibit the application of couplers in the critical area of columns (e.g. AASHTO Guide Specifications, Article 8.8.3), recent studies have revealed the feasibility of precast columns utilizing couplers in the plastic hinge regions helping expanding ABC in high seismic zones. The seismic performance is not a concern for none- or low-seismic states. Nevertheless, the application of bar couplers in precast bridge columns located in these states is also scarce probably because of the uncertainty pertaining to the coupler performance, column connection</p>

performance, and an engineering precaution. Utah, Florida, Colorado, and Washington have incorporated grouted sleeve bar couplers for bridge columns.

There are several types of couplers in the market and new coupler types are emerging. Their prime role is to shorten the splice length and to reduce bar congestion in connections. Since bridge columns are the focus of the present study, couplers that transfer both tensile and compressive forces are investigated. Five suitable coupler types are (Fig. 1): shear screw couplers, (2) headed bar couplers, (3) grouted sleeve couplers, (4) threaded couplers, and (5) swaged couplers.

The PI recently conducted a research funded by the US Department of Transportation through the University Transportation Center - Accelerated Bridge Construction (ABC-UTC). A state-of-the-art literature review was conducted in this study to investigate the coupler performance as well as the performance of mechanically spliced columns. It was found that the available test data is not sufficient to conclusively comment on the suitability of couplers for precast column construction. A comprehensive testing schedule was recommended to investigate the coupler performance for ABC applications (Tazarv and Saiidi, 2015).

Due to a lack of test data, the PI developed an analytical method to include the effect of mechanical bar couplers on the performance of precast bridge columns. A generic material model was proposed (Fig. 2) for all coupler types assuming that a portion of the coupler is rigid (βL_{sp}) and does not contribute to the splice overall elongation. β is defined as the coupler rigid length factor. Therefore, for the same tensile force, the coupler region axial deformation will be lower resulting in a lower strain in the coupler region (ϵ_{sp}) compared to the strain of the connecting reinforcing bar (ϵ_s):

$$\epsilon_{sp}/\epsilon_s = (L_{cr} - \beta L_{sp})/L_{cr} \quad (\text{Eq. 1})$$

where L_{cr} is the length of the coupler region and L_{sp} is the coupler length. Overall, the stress-strain relationship for any type of mechanical bar splices can be determined by knowing only the coupler rigid length factor (β).

A comprehensive parametric study was carried out to investigate the coupler effect on the mechanically spliced bridge column displacement capacity. It was found that stiffer couplers closer to the column ends can reduce the column displacement capacity by 40% compared to the non-spliced conventional columns. Subsequently, a simple design equation was proposed to further aid the designers. Even though the study by Tazarv and Saiidi (2015) provided a better understanding of the coupler behavior and their effects on column performance, a comprehensive testing schedule is needed to establish the coupler behavior and to develop design guidelines for the field deployment of mechanically spliced precast bridge columns.

<p>Describe Implementation of Research Outcomes (or why not implemented)</p> <p>Place Any Photos Here</p>	<p>Data regarding the performance of mechanical bar couplers is inconclusive especially when couplers are used in precast bridge column construction. This research provides a comprehensive database on the mechanical properties of bar couplers with a recommendation on the suitability of each coupler for ABC column connections. The information generated under this project will benefit all 50 states since ABC is gaining a substantial momentum in the US due to significantly lower onsite construction time and potentially lower cost that it offers over the conventional construction. Tazarv and Saiidi (2015) showed that bridge bents with coupler connections at column ends can be built three times faster than bents built cast-in-place.</p>
<p>Impacts/Benefits of Implementation (actual, not anticipated)</p>	<p>This project will provide a valuable learning experience to both graduate and undergraduate students. An MSc graduate student will be hired to work on this project which will provide the material for a master thesis. An undergraduate student hired for this project will benefit from the experimental exposure and will learn the research process. Results from the study will be incorporated into courses such as Advanced Reinforced Concrete and Bridge Design.</p>
<p>Web Links</p> <ul style="list-style-type: none"> • Reports • Project Website 	<p>https://www.ugpti.org/resources/reports/details.php?id=932</p>