UTC Project Information	
Project Title	MPC-545 – Self-Centering Bridge Bent for Accelerated Bridge Construction in Seismic Regions
University	University of Utah
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Total Project Cost	$222,835
Agency ID or Contract Number	69A3551747108
Start and End Dates	November 15, 2017 to July 31, 2022
Brief Description of Research Project	Current design philosophy in bridge design for seismic regions aims to reduce residual displacements after an earthquake. After the Kobe earthquake, Japanese design criteria for bridges have changed to require designers to limit permanent drifts to less than 1% (Japan Road Association 2002). The aftermath of the Christchurch earthquake has highlighted difficulties in assessing future performance and repair of damage to plastic hinge zones in conventional reinforced concrete structures (Routledge et al. 2016). Low-damage ductile-jointed systems have been developed to control damage in plastic hinge regions and avoid residual displacements. These systems provide self-centering capability using un-bonded post-tensioning and axial load, and provide energy dissipation through yielding of non-prestressed reinforcement or yielding dampers. Unbonded post-tensioning, in which prestressing forces are introduced at the construction site during the erection process has been proposed for reducing residual displacements after an earthquake. Post-tensioning was combined with high-performance cementitious materials to limit damage in the hinging region by Billington and Yoon (2004). Mahin et al. (2005), Cohagen et al. (2008), Motaref et al. (2010), Restrepo et al. (2011), and Guerrini et al. (2015) who studied the benefits of introducing post-tensioning into bridge columns. However, post-tensioning which is an extra step performed at the bridge site can delay construction because of the jacking operation. In addition, stress concentration where a wedge grips the unbonded strands may reduce the cyclic stresses that anchorages can withstand (Walsh and Kurama 2012).

Post-tensioning

Shake table tests of single and two-column bents with a central unbonded, post-tensioned tendon showed good recentering capability (Mahin et al. 2005); however, some mild steel bars buckled. In one specimen, a steel jacket combined with debonding of mild steel achieved high displacement ductility with no apparent damage. Quasi-static cyclic tests of half-sized columns for a column-to-footing and column-to-cap beam connection using a central unbonded, post-tensioned tendon showed that increases in posttensioning force led to slight increases in damage at high drift ratios (Cohagen et al. 2008). For this reason, more tendons should be used and the initial post-tensioning force should be reduced. One-third scale columns were tested on a shake table without a complete connection of a column to a footing and cap beam; a central unbonded, post-tensioned tendon was used (Motaref et al. (2010). Fast assembly, minimal damage at the plastic hinge area, and minimum residual displacement were observed in both column models. A precast post-tensioned composite steel-concrete hollow-core column was combined with supplemental energy dissipation to minimize post-earthquake residual lateral displacements (Guerrini et al. 2015). The column consisted of two steel cylindrical shells, with high-performance concrete cast in-between. Both shells acted as permanent formwork; the outer shell was used to substitute the longitudinal and transverse reinforcement, whereas the inner shell removed unnecessary concrete volume from the column, prevented concrete implosion, and buckling of energy dissipating dowels.

Grouted ducts

For the proposed research, the embedment length of reinforcing bars inside galvanized grouted ducts has to be determined. In addition, embedment of the grouted ducts themselves needs to be determined for good performance. From previous research on pullout strength of large reinforcing bars including #18 bars for monotonic loads carried out by Steuck et al. (2009), it is known that yield and fracture can be achieved with embedment lengths of 6 and 10 bar diameters, respectively; however the grout average compressive strength used was only 8,250 psi. Raynor (2000) proposed that development length for cyclic loads should be 40% longer than for monotonic loads. Tazarv and Saiidi (2014) proposed development length equations controlled by either the length of the steel bar or the galvanized duct length; the grout had an average compressive strength of 24,200 psi and monotonic load was used for the pullout tests; the bar development length was found to be inversely proportional to the square root of the grout compressive strength. For a grout with a compressive strength equal to 13,000 psi which is expected to be used in this research, the development length of the bar could be reduced by a factor equal to $\sqrt{(8.25/13.0)} = 0.80$. The resulting development length factor for combining cyclic load and high strength grout is thus expected to be equal to $1.40*0.80 = 1.12$.

	Duct size was found to have a significant effect on bond strength in the tests by Tazarv and Saiidi (2014); they recommend that the duct diameter for single column longitudinal bars should not be less than 3 times the bar diameter. Caltrans SDC (2013) recommends that the cap beam depth must be sufficient to develop the column longitudinal reinforcement without hooks. Straight column longitudinal bars should extend 24 bar diameters into the cap beam. Research Objectives: 1. Develop and test under cyclic loads alternative methods for constructing bridge bents in high seismic regions using self-centering in terms of post-tensioning of bridge columns 2. Develop analytical models for self-centering in terms of post-tensioning of columns in bridge bents under cyclic loads, which will assist in the design and implementation of such bridges 3. Present the results at national conferences and journal publications Accelerated Bridge Construction (ABC) has been practiced in many parts of the country; however, in high seismic regions the challenge of providing ductile connections between columns and footings and columns and pier-caps is a topic of research currently still in progress. All similar research carried out so far on post-tensioned columns has considered a single bridge column. The proposed research considers a two-column bent with scaled dimensions representing an actual bridge bent that has been built in the state of Utah. Moreover, the debonding of the steel bars is an innovative feature that is expected to improve displacement ductility of the bridge bent.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	
Web Links • Reports • Project Website	

UTC Project Information	
Project Title	MPC-546 – Field Performance of Asphalt Pavements at Low and Intermediate Temperatures
University	University of Utah
Principal Investigator	Pedro Romero
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Funding Source(s) and Amounts Provided (by each agency or organization)	USDOT, Research and Innovative Technology Administration $60,000 Utah Department of Transportation $120,000
Total Project Cost	$180,000
Agency ID or Contract Number	69A3551747108
Start and End Dates	November 15, 2017 to July 31, 2022
Brief Description of Research Project	Within its current practice, state transportation agencies are using aggressive rutting and stripping testing to qualify asphalt mixes for use in highway construction. This practice was in response to the typical distresses found in pavements from the late 1980s and early 1990s. In most states, this has generally resolved rutting issues, but has led to a detrimental effect on cracking and raveling behavior in the pavements. This one-dimensional approach has been recognized as a challenge to be addressed within the mix design process and highway agencies have been looking for practical tests to provide a performance balance and increase mix durability. Asphalt mixes now contain Recycled Asphalt Pavement (RAP) and less asphalt binder, both virgin and total, in an attempt to resist rutting and save on materials. Furthermore, with the high cost of asphalt binder and the increase in available substitutes and modifiers, asphalt binder testing alone is no longer adequate to predict pavement performance thus mix performance testing at all temperatures is becoming increasingly important. Building a mix to avoid both rutting and cracking requires a balance of priorities because these behaviors are often in direct conflict with each other. However, in the absence of practical tests, mix design and acceptance programs currently favors rutting resistance, leaving a clear imbalance and skewed performance. As the practice continues, these effects are becoming more pronounced; should current practices continue without adjustment for durability performance, constructed pavements will continue to exhibit early age cracking (both thermal and fatigue) and the performance of the pavements will be significantly affected, leading to a significant loss of investment by highway agencies.

	A new test to evaluate low temperature performance of asphalt mixtures was developed with previous funding assistance from the MPC. This test uses the existing Bending Beam Rheometer (BBR) to test asphalt mixes. Test protocols were created for both cores and laboratory compacted samples and the relation to pavement performance was determined. This test was voted as an AASHTO provisional specification (TP-125) and could soon be adopted as a requirement for asphalt mix design. In a parallel effort, the Semi-Circular Bending/Fracture Energy test (SCB) was determined as a feasible test for intermediate temperature performance and was also voted as an AASHTO provisional specification (TP-126). By using these two tests (BBR and SCB) mixes can be evaluated for cracking potential in regards to RAP content, asphalt binder content, binder modification, etc., resulting in a complete performance-related specification. However, adoption of any pavement performance specification requires an understanding of ALL aspects of mixture design including factors like: How will the new requirement affect the binder content? How will the new requirement affect the durability of asphalt pavements? How will the requirement affect current rutting tests (i.e., Hamburg WTD results)? How do all of these tests complement each other? This research will attempt to answer these questions by evaluating selected asphalt mixtures for low temperature cracking, intermediate temperature fracture energy, and high temperature deformation (rutting) to ensure that the addition of a low temperature test will not affect the high temperature performance or the durability of pavements. This work will allow for better optimization of mixes and reduction of poor performance potential of highway assets. Therefore, this work will have relevance at a regional and national level. Research Objectives: 1. Determine the intermediate temperature properties of representative asphalt mixtures produced in the state of Utah 2. Determine the low temperature properties of representative asphalt mixtures produced in the state of Utah 3. Compare the laboratory measured properties of asphalt mixtures and their material design to their corresponding short-term field performance 4. Present results at a national level The overall objective of this work is to determine if the BBR and the SCB test, based on AASHTO TP125 and 126, respectively, can be used to predict the short-term (first year) low- and intermediate-temperature field performance of asphalt mixtures (i.e., cracking). At the conclusion of this project, we will be able to know if these tests could be used as practical alternatives to screen, or even eliminate,

	asphalt mixtures that result in poor cracking performance once placed in the field.
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