UTC Project Information	
Project Title	MPC-447 - Post-Fire Ground Treatments for Protection of Critical Transportation Structures (Year 2)
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Project Cost	$30,000
Start and End Dates	September 30, 2013 to September 30, 2018
Project Duration	September 30, 2013 to September 30, 2018
Brief Description of Research Project	The following objectives will be completed as part of the proposed project: 1. Evaluate effects of fire on soil composition, soil shear strength, and moisture retention; 2. Evaluate the efficacy of post-fire ground treatments on mitigating erosion and runoff; 3. Evaluate the effects of percent ground cover, slope angle, and rainfall intensity on erosion and runoff; and 4. Develop preliminary guidelines for post-fire feasibility assessments focused on ground treatment applications to prevent loss of or damage to critical transportation components. These research objectives will be completed via a coupled experimental and numerical research program. Objectives 1 and 2 will include laboratory experiments to understand the mechanisms of post-fire ground treatments that contribute to soil stabilization and obtain physical data necessary for calibration of numerical models. Objective 3 will be completed using discrete element models such that different combinations of variables affecting ground treatment performance can be evaluated (i.e., percent ground cover, slope

	angle, and rainfall intensity). The combined experimental and numerical research will be used to develop emergency stabilization recommendations in Objective 4. Wildfires are a natural phenomenon in Colorado and the Western U.S., and the frequency of large, destructive wildfires has increased over the past decade and is forecasted to continually increase due to climate variability (Robichaud et al. 2010). Over 30 million acres of land have been burned by wildfires in the U.S. in the last five years alone. Potential damage to the human and built environments is not only associated with burned lands, homes, and infrastructure during a wildfire, but can extend for years following a wildfire in the form of increased runoff from precipitation, soil erosion, and debris flows. The frequency and magnitude of runoff, soil erosion, and debris flows increases following a wildfire due to burned surface vegetation that reduces soil cover, increased raindrop impact from loss of foliage, and/or soil hydrophobicity that can inhibit infiltration and water retention (e.g., Larsen et al. 2009; Santi et al. 2013). The prevalence of increased runoff, erosion, and debris flows along transportation corridors can lead to damage of critical infrastructure (e.g., roads, bridges, culverts, etc.). Potential post-fire impacts include damage to the road system caused by increased run-off rates that overwhelm design limits for culverts and bridges, severe erosion of the road surface, and blocking of hydraulic structures by debris and sediment. Post-fire ground treatment that minimizes damage to transportation infrastructure is focused on emergency soil stabilization to mitigate erosion and runoff and generally is implemented within a 1-yr period following a fire. In addition to soil stabilization, post-fire ground treatment enhances burned area restoration to mitigate future land damage and facilitate repair of damaged infrastructure. The state-of-practice in post-fire ground treatment primarily includes erosion barriers, mulching, chemical soil treatments, or a combination of these options (Robichaud et al. 2010). Erosion barriers include contour trenches, straw bales or wattles (straw-filled mesh tube), and felled logs that inhibit runoff and erosion while retaining moisture and sediment upslope to enhance regeneration of vegetation. Mulching refers to ground-cover treatments (e.g., agricultural straw or wood chips) that are surface applied to reduce raindrop impact and minimize erosion and overland flow (Bautista et al. 2009). This treatment can also increase infiltration and soil moisture content to enhance root uptake and vegetative regeneration. The predominant chemical soil treatment is hydromulching, which is a slurry-applied mixture of mulch, seeds, and nutrients designed for the advantages of mulching plus enhanced vegetative regeneration. Mulching and hydromulching are becoming the preferred ground treatment alternatives for emergency response required over large land areas and/or in short timeframes. The estimated cost for post-fire emergency response actions following the 2012 High Park Fire in Larimer County was $24M (million USD). Included

	in this cost was $12.6M for mulching of post-burned slopes and $6.6M for increasing culvert size in anticipation of increased runoff and erosion (BAER 2012). Gorte (2011) report that federal funds expedited for post-fire rehabilitation is an increasing concern as expediting funds and corresponding rehabilitation actions can lead to inappropriate emergency actions in absence of a detailed feasibility study. This process can result in potentially greater future environmental damage. A similar argument can be made in regards to funds and actions expedited at the state level, and in general, post-fire ground treatment actions remain ad hoc with a need for knowledge of short-term and long-term benefits accompanying different treatment alternatives. The main objective of this study is to assess the efficacy of post-fire ground treatments in mitigating soil erosion, runoff, and debris flows towards developing guidelines for conducting needs and feasibility assessments to enhance post-fire emergency response actions. A coupled laboratory and numerical research program will be used to determine a priori means for assessing post-fire ground treatments for soils near critical transportation infrastructure.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	The primary deliverable of the proposed research will be post-fire ground treatment recommendations to improve emergency stabilization efforts based on protection of critical transportation resources. Performance-based assessments from the research program will yield ground treatment recommendations that are both economical and sustainable. The developed recommendations will integrate treatment method, slope angle, and climate conditions and also address susceptibility of transportation infrastructure to damage with and without ground treatment application. Practitioners within public and private sector will have the ability to make judicious post-fire soil stabilization decisions and focus initial efforts in critical infrastructure areas. This timely response will decrease the potential for infrastructure damage from runoff, soil erosion, or debris flows. The coupled experimental and numerical research program will yield innovative tools to assess the efficacy of varying ground treatment alternatives. Successful implementation of the research program will provide an assessment strategy for future site evaluations and design alternatives. Thus, future innovative ground treatments that are promising alternatives to current approaches can be evaluated according to a mechanistic-based approach that yields results targeted towards field implementation. Additionally, the systematic evaluation of soil characteristics, laboratory-scale behavior, and numerical modeling will generate data necessary to support a mechanistic-based field-scale ground treatment evaluation. This type of mechanistic evaluation of post-fire soil stabilization will aid in establishing proof-of-concept for the proposed research and enhance subsequent adoption of developed tools into practice.

Impacts/Benefits of Implementation (actual, not anticipated)	The proposed study will support two graduate students; one student will lead experimental research efforts and the other student will lead numerical research efforts. The students and Principal Investigators (PIs) will create a synergistic collaboration such that all personnel understand the integration of the proposed research tasks to further the state-of-practice of post-fire ground treatments and improve protection of transportation infrastructure. Experience gained by the PIs will be blended into undergraduate and graduate courses taught by the PIs to provide students tangible connections to a relevant civil engineering problem that we as a society will face for the foreseeable future. The laboratory and numerical tools will be invaluable teaching aids to demonstrate how coupling laboratory experiments and numerical modeling can enhance our ability to solve challenging, multi-disciplinary engineering problems.
Web Links • Reports • Project Website	