UTC Project Information	
Project Title	MPC-411 – Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthwork Projects
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Funding Agencies	USDOT, Research and Innovative Technology Administration
Agency ID or Contract Number	DTRT12-G-UTC08
Project Cost	$130,000
Start and End Dates	June 1, 2013 - June 1, 2015
Project Duration	2 Year
Brief Description of Research Project	Environmental sustainability and land stewardship are challenging but laudable constraints for all infrastructure development in the United States. Our nation's prevalent energy concerns, which include the desire for energy independence coupled with a growing population requiring additional energy capacity, constrain energy available to repair and build new infrastructure. The Colorado Department of Transportation (CDOT) has identified the maintenance and improvement of roadways in addition to increased construction of local road systems as strategic goals in the statewide transportation plan (CDOT 2008). These goals will support an overarching objective in Colorado to enhance transportation safety while meeting future needs of increased transportation capacity. Improving roadway construction and initiating new transportation-related construction projects throughout Colorado will require a broad array of earthwork constructions, such as road subbase and subgrade, un-paved roadways, embankments, and fills. Each of these earthwork projects requires earthen materials (e.g., soil or crushed rock) that are constructed in a manner to obtain optimal performance. The use of recycled materials, such as mine waste (mine waste rock and tailings) and coal combustion residuals (CCRs), has the potential to aid transportation-related construction needs while decreasing energy consumption, raw material use, and greenhouse gas emissions. Mine waste materials include waste rock discarded from mining operations and fine-grained tailings produced during ore extraction processes (Wickland et al. 2006). Coal combustion residuals include fly ash, bottom ash, boiler slag, and flue-gas desulpherization, which are all by-products generated at coal-fired power plants (ACAA 2012). Recent studies on innovative

	mine waste management practices have demonstrated the applicability of mine waste rock and tailing co-disposal (i.e., mine waste and tailings mixtures) that can mitigate acid rock drainage from mine waste rock and low shear strength in tailings (Wickland et al. 2006). Additionally, the re-use of CCRs, in particular fly ash, in transportation-related earthworks has been reported to enhance soil strength and durability with negligible environmental effects from introducing CCRs into natural environments (e.g., Lee et al. 2010). The proposed study will evaluate the efficacy of creating a sustainable earthen material from mixtures of mine waste rock and tailings, stabilized with fly ash, which meets performance and environmental constraints for use as a construction material in transportation-related earthwork projects. **Research Objectives:** The following objectives will be completed as part of the proposed project to evaluate the hypothesis that mixtures of mine waste rock, tailings, and fly ash have satisfactory performance to warrant re-use as a sustainable geomaterial in transportation-related earthwork projects. 1. Evaluate and summarize the current state-of-practice and state-of-art in re-use of mine waste materials and fly ash in geotechnical projects related to transportation construction, with particular emphasis on projects in Colorado. 2. Assess the efficacy of creating mixtures of mine waste rock and tailings with and without fly ash that have adequate geotechnical and geoenvironmental properties (i.e., shear strength, compressibility, hydraulic properties) for use in transportation-related projects. 3. Optimize the mine waste mixture ratio, amount of fly ash addition, and specimen preparation method that produces a material with geotechnical and geoenvironmental characteristics ideal for field implementation and evaluation. 4. Data analysis and report writing combined with preparation of peer-reviewed conference and journal papers for dissemination of research results.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	The influence of fly ash-amendment on hydraulic conductivity of mine tailings was attributed to molding water content and plasticity of the mine tailings. Silty tailings exhibited a decrease in hydraulic conductivity when amended with fly ash and prepared wet of optimum, whereas clayey tailings exhibited a one-order magnitude increase in hydraulic conductivity with addition of fly ash and prepared dry or near optimum. In general, unconfined compressive strength increased with an increase in tailings particle size, solids content, and/or increase in CaO-to-SiO2 ratio of fly ash for amended tailings specimens. An increase in strength of mine tailings amended with fly ash was also observed

	as a break in slope on a compression curve, which was identified as the breaking stress. The breaking stress increased with an increase in fly ash content, which was attributed to a lower water-to-binder ratio that produced more effective particle bonding.
Impacts/Benefits of Implementation (actual, not anticipated)	Hydraulic conductivity results indicated that curing time had minimal impact on hydraulic conductivity after 7 days of curing, which can shorten test programs on actual projects. A multivariate regression model was developed to predict unconfined compressive strength of tailings amended with fly ash as a function of (i) tailings water content, (ii) water-to-binder ratio, and (iii) CaO-to-SiO2 ratio of fly ash. Breaking stress in compressibility tests increased with an increase in CaO content and CaO-to-SiO2 ratio of fly ash, which resulted in more effective bonding between particles. An improved understanding of the combined properties of mine waste and fly ash will improve reuse potential of these materials in earthwork construction.
Web Links • Reports • Project Website	http://www.ugpti.org/resources/reports/details.php?id=890