Identifying Number MPC-339

Project Title:

MEPDG Analysis Of ESR Subgrade Stabilized With Off-Specification Fly Ash

University:

Colorado State University

Principal Investigator:

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Description of Research Problem:

Previous research directed by the PI and sponsored by USDOT-MPC and other agencies have shown that the swell potential of expansive soils can be mitigated by addition of scrap tire rubber to the expansive soil (Seda et al. 2007; Carraro et al. 2010b). The swell pressure of Expansive Soil-Rubber (ESR) mixtures may be reduced to about 15-30% of the swell pressure of the untreated expansive soil, whereas the swell percent of ESR mixtures may be reduced to about 25-40% of the swell percent of the untreated expansive soil (Carraro et al. 2010b). These are desirable characteristics for consideration of these mixtures as alternative pavement subgrade, embankment and bridge abutment backfill materials.

The above studies have also quantified the stiffness reduction associated with rubber addition to expansive soils. The PI's ongoing USDOT-MPC project is focusing on the improvement of ESR stiffness using off-specification fly ash, which is a type of fly ash with very limited use in Civil Engineering applications. In Colorado, the beneficial use of off-specification fly ash in Civil Engineering applications is nonexistent. Results from this ongoing study suggest that properly designed ESR mixtures can be successfully stabilized with off-specification fly ashes. The stiffness of ESR mixtures that are properly designed and stabilized with off-specification fly ash can be restored to the stiffness values observed for the compacted, untreated soil (see please small-strain stiffness values in Fig. 1). This mitigates the undesirable stiffness reduction effect imparted by rubber addition while increasing the critical-state shear strength of the stabilized ESR mixtures to levels higher than those observed for the soil alone (see large-strain data on Fig. 2).

The main aspects related to the mechanical response of ESR mixtures stabilized with off-specification fly ash will be fully evaluated by the end of the PI's ongoing USDOT-MPC project (Carraro and Wiechert 2010). Field construction guidelines using these mixtures have already been developed by another project directed by the PI (Carraro et al. 2010). Therefore, the next step towards implementation of the technology in practice involves

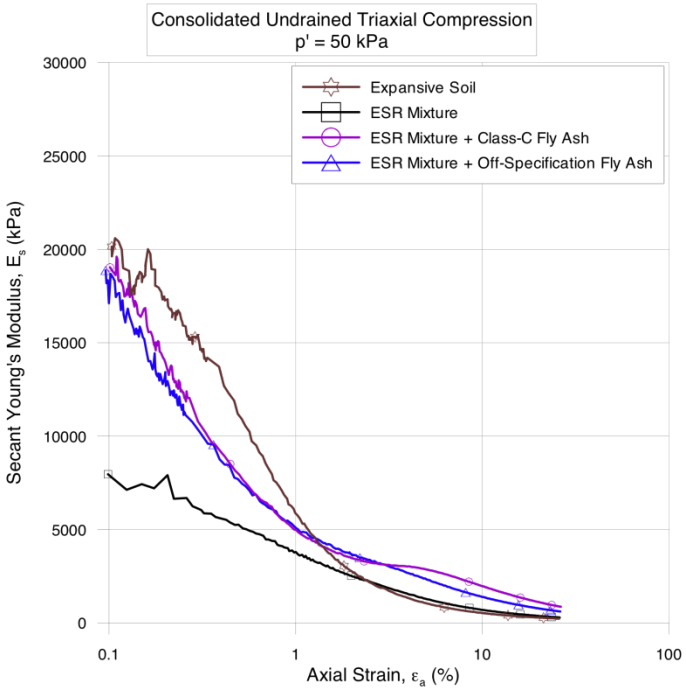

Figure 1 – Stiffness degradation response in triaxial compression

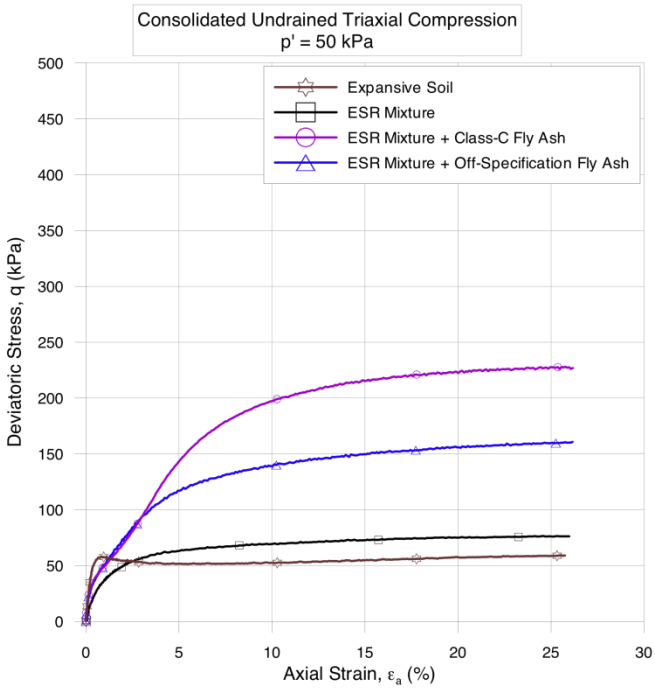

Figure 2 – Stress-strain response in triaxial compression

carrying out a systematic parametric study to simulate the performance of the proposed technology in specific civil engineering applications. One such potential application may be related to the use of ESR mixtures stabilized with off-specification fly ash as a pavement subgrade layer. This project focuses on the beneficial use of both scrap tire rubber and off-specification fly ash in a cemented, self-encapsulating environment, similar to the beneficial use of fly ash in Portland cement concrete. The beneficial use of fly ash either in concrete or in the application proposed in this project is far different from uses in impoundments and embankments, where the leachate can contaminate groundwater with chemicals that include cadmium and arsenic (ENR 2010).

Research Objectives:

The goal of this project is to synthetically evaluate the performance of ESR mixtures stabilized with off-specification fly ash as a pavement subgrade layer using the Mechanistic-Empirical Pavement Design Guidelines (MEPDG)

framework. The results of these simulations will be disseminated among the network of collaborators that have been supporting the PI's research over the last four years including: Colorado Department of Transportation, City of Loveland's Department of Public Works, American Coal Ash Association, Platte River Power Authority, Caliber Recycled Products Inc., and Front Range Tire Recycle Inc., as well as civil engineering students at CSU.

Research Approach / Methods:

Project tasks include:
Task 1 – Resilient Modulus Testing: in order to complement the static triaxial compression stiffness data from Carraro and Wiechert (2010), the resilient modulus (M_r) of a select ESR mixture stabilized with off-specification fly ash will be determined using the design parameters (i.e., compaction water content, relative compaction and rubber content) recommended by Carraro and Wiechert (2010).
Task 2 – Computer Simulations: the MEPDG software and framework will be used to evaluate the performance of various pavement subgrade layers of ESR mixtures stabilized with off-specification fly ash.
Task 3 – MEPDG-Based Pavement Subgrade Design: pavement subgrade layers will be designed based on the results from the MEPDG analyses (Task 2) and the compaction lift thickness recommended by Carraro et al. (2010a) for construction of ESR mixtures.
Task 4 – Report writing: write up of the final USDOT/MPC technical report and technical paper.
Task 5 – Technology transfer: a technical paper will be prepared and presented at a local workshop for the project collaborators and CSU students, and at a national ASCE conference.

MPC Critical Issues Addressed by the Research:

1. Improved Infrastructure Design.
2. Infrastructure Longevity.
3. Environmental Impacts of Infrastructure.

Contributions / Potential Applications of Research:

Potential applications of the proposed technology include the use of ESR mixtures stabilized with off-specification fly ash as embankment, bridge abutment or backfill material in low-volume road and bridge construction in areas where expansive soils abound. Collaboration with state and local transportation agencies will allow faster implementation of MEPDG guidelines in Colorado.

Potential Technology Transfer Benefits:

Research products include (1) mentoring of a qualified graduate student and (2) publication and presentation of a peer-reviewed paper. Project will allow the PI to strengthen previous collaborations with state and local transportation agencies, and local fly ash and rubber suppliers. Significant environmental benefits will result from large-scale recycling of waste tires and coal combustion products and their diversion from landfills in Colorado. Research information will be disseminated to a national audience at the 2011 ASCE Geo-Institute Annual Conference.

Time Duration:

July 1, 2010 – June 30, 2011

Total Project Cost:

$94,036

MPC Funds Requested:

$52,000

Source of Matching Funds:

Colorado State University and External Collaborators: $42,036

TRB Keywords: MEPDG, Low-Volume Roads, Mechanistic Design, Sustainability, Recycled Materials, Stiffness, Resilient Modulus.

References

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