

Use of Solid Wastes in Asphalt and Concrete in Florida

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ABSTRACT

This proposal outlines research designed to provide needed technical information pertaining to the use of waste-derived materials in the manufacture of Portland cement concrete and asphalt pavement used in road construction (and similar applications). The research builds upon existing work on WTE bottom ash in these applications, but the results are designed to provide data that will be helpful for beneficial use of other waste materials. In addition to conducting an extensive literature search, the research team will focus on three research activities. First, the variability of the particle size distribution of WTE bottom ash, both among facilities and over time) will be evaluated at five Florida WTE facilities. Second, several issues regarding the long-term performance related to waste-amended concrete will be researched. Third, the potential to gage the mobility of chemical contaminants from concrete and asphalt pavement products using standard materials characterization tests will be explored.

INTRODUCTION AND BACKGROUND

The use of waste materials as ingredients in Portland cement concrete and asphalt pavement has long been proposed as a potential end-market for many waste materials. The most successful example of such an application has been the use of coal fly ash in concrete production. Other wastes have been proposed as candidate concrete and pavement ingredients (waste to energy ash, rice ash, ground glass, coal bottom ash), but widespread utilization of these materials has not developed because of a variety of performance, environmental, and economic issues. In recent years, interest in such beneficial uses has been renewed. The proposal team has been working with the Hinkley Center on waste materials recycling in road construction for the past several years, including the construction of a test road strip utilizing WTE bottom ash as a construction material.



Figure 1: Hot mix asphalt and Portland cement concrete pavements with WTE bottom ash included as a partial aggregate replacement being placed as part of a pilot project at the Pasco County Resource Recovery Facility.

This proposal addresses item 15 on the 2014 Hinkley Center RFP.

The design, permitting, and construction of the roadway test strips at the Pasco County Resource Recovery facility required the research team to test both physical and environmental properties of waste-amended concrete and asphalt pavement. This work was conducted in the team's laboratories at the University of Florida and at the FDOT's State Materials Office laboratory. Throughout this process, a number of unexplored research questions that relate directly to the Center's stated research objective were identified. Feedback from the FDOT indicated the importance of the particle size distribution of the waste to energy bottom ash if it were to be used in an actual road construction project; variability in gradation would have a substantial impact on the mix design. The high absorption of the ash when used as a course aggregate resulted in an increase in the asphalt binder needed. The increase in asphalt binder would result in the production of a higher cost product.

Testing of the concrete during the Pasco county project indicated the need for further examination of the relative durability of ash amended PCC. Deleterious effects related to alkali silica reaction from bottle glass (Kou et al., 2009), expansion due to the pozzolanic properties of the bottom ash, and hydrogen gas formation were noted as potential challenges related to use in PCC pavement. These phenomena are supported by other published studies (Pera et al., 1997; Muller and Rubner, 2006; Biganzoli et al., 2013) Before PCC amended with WTE bottom ash could be used in a full scale application measures to help mitigate some of these potential problems need to be explored.

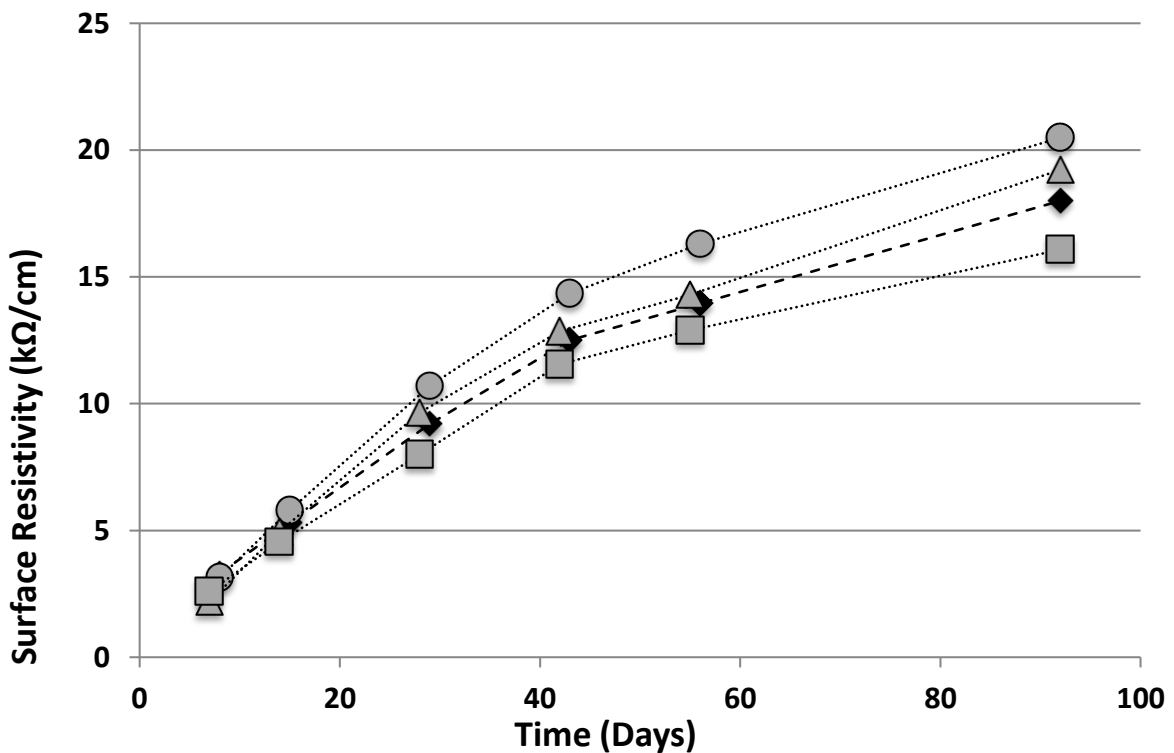


Figure 2. Surface resistivity from ash amended concrete

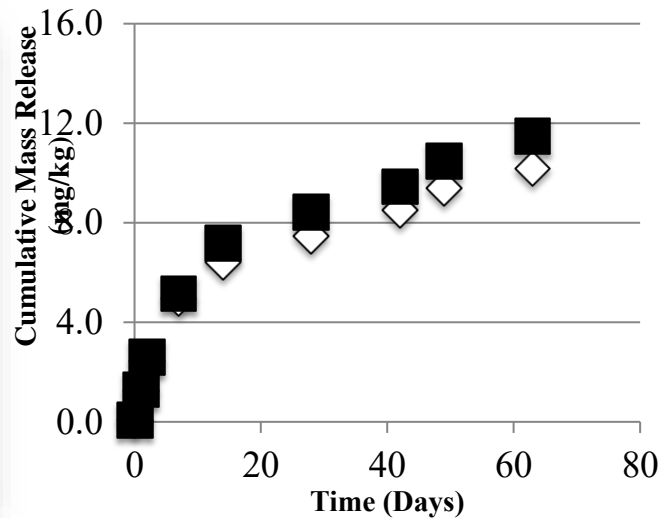


Figure 3. Monolith specimens of asphalt and concretes, an example of data from a Method 1315 test

With the US EPA's new suite of leaching tests (LEAF) there are a number of tools available for assessing contaminant release from wastes. One of these is a test where the material is leached in its monolithic form. This test allows researchers and scientists to evaluate trace element diffusion from a material in the form that it would be in when beneficially used. This can be helpful in predicting site concentrations using an engineering analysis (fate and transport modeling). It is known the permeability of a material can impact the diffusion of constituents from its matrix; there are known methodologies for assessing the permeability of asphalt and concrete. These methods are often less time intensive than the laboratory leach testing described above. Developing a correlation between PCC and HMA permeability and constituent release from the monolithic material would allow for a quick test to assess the relative potential for constituent release from a road construction material (amended with bottom ash or other waste materials).

INVESTIGATOR QUALIFICATIONS

The investigators for the proposed research are Timothy Townsend, a Professor in the Department of Environmental Engineering Sciences and Chris Ferraro, a Research Assistant Professor in the Department of Civil and Coastal Engineering, both at the University of Florida. Dr. Townsend's area of specialization is solid and hazardous waste management and engineering. He has conducted research on numerous areas of solid waste management in the last 25 years, including specific projects on waste leaching and characterization of wastes for beneficial use. Dr. Townsend's laboratories have the capabilities for analysis of trace elements using inductively coupled plasma atomic emission spectrometry, ion chromatography and a number of other analytical techniques and graduate students familiar with operating these instruments and conducting leach testing. Dr. Ferraro's area of specialization is behavior of the physical and chemistry of infrastructure materials, the use of alternative pozzolans in cementitious materials, and nondestructive testing of Portland cement concrete materials. Both Drs. Townsend and Ferraro have worked extensively with the waste to energy industry as well as the regulatory communities in Florida (FDEP, FDOT).

OBJECTIVES

The specific objectives of the research project are as follows:

- Provide a comprehensive literature review of the use of waste materials in Portland cement concrete and asphalt pavement, and identify primary candidate waste materials for use in Florida.
- Conduct a statewide assessment of WTE bottom ash gradation from Florida WTE facilities and evaluate differences in ash specific gravity and adsorption.
- Conduct research to examine the longer term behavior of WTE bottom ash as an aggregate in PCC and provide condition for production conditioning and waste amendments. Specific long-term behavior issues include examining the potential for (1) expansive gel formation due to alkali silicate reactions, (2) expansive behavior due to pozzolanic behavior of waste materials, and (3) hydrogen gas formation.
- Provide guidance for evaluating environmental risk from waste materials in PCC and asphalt pavement.

METHODOLOGY

Task 1. Literature review and needs assessment. Current literature with regard to the application of leaching protocols such as LEAF will be compiled. This will include an evaluation of the refereed literature, industry and government documents, and international experience with application of leaching protocols.

Task 2. Statewide assessment of WTE bottom ash gradation. The research team will examine the gradation of WTE bottom ash from a minimum of five facilities in Florida. The research team has been working with the Florida WTE utilities for the past few years as part of previous Hinkley Center projects and has established the relationships to accomplish this. Daily composite samples will be collected for five days from each of the five facilities. The samples will be then be characterized using ASTM method C136 (Standard test method for fine and coarse aggregates).

Task 3. Long-term concrete performance research. Samples of the WTE bottom ash will be used to produce laboratory concrete specimens. These specimens will be subjected to a variety to tests to evaluate the formed microstructure as it pertains to concrete amended with WTE bottom ash. The tests will include microscopic analysis, evaluation of alkali silica reactivity, hydrogen gas evolution potential, and pozzolanic activity capacity. Physical properties (including concrete strength and modulus of elasticity) on the products will be measured.

Task 4. Leach testing. The potential for chemical release from a waste-amended concrete or asphalt product when exposed to water is hypothesized to relate to the permeability of the products. Representative samples of ash-amended concrete and asphalt pavement will be subjected to a series of physical tests to characterize permeability and compared to the results of environmental leach testing. PCC samples will be characterized using electrical resistivity (AASHTO TP95, Standard method of tests for surface resistivity indication of concrete's ability to resist chloride ion penetration), a surrogate for concrete permeability. The hydraulic conductivity of the asphalt samples will be measured using FDOT FM5-565 (Florida method of test for water permeability of compacted asphalt paving mixtures). Representative replicates of all samples will be tested using EPA Method 1315 (Mass transfer rates of constituents in monolithic or compacted granular materials using a semi-dynamic tank leaching procedure). The results of the different tests will be compared and evaluated.

DELIVERABLES

Deliverables for the proposed work include progress reports to the Center, the preparation of a final technical report and any manuscripts or thesis chapters completed by students working on this project as part of their degree requirements. All other deliverables required by the Center will be met. A project website will be maintained, an information dissemination plan will be developed, and other necessary deliverables will be completed.

A 12-month project is proposed with the following timeline:

Task	1	2	3	4	5	6	7	8	9	10	11	12
1. Literature review	X	X	X									
2. Statewide assessment of WTE bottom ash gradation			X	X	X	X						
3. Long-term concrete performance research						X	X	X	X	X		
4. Leach testing							X	X	X	X	X	
TAG Meeting			X								X	
Final report												X

BENEFITS

The solid waste community in Florida will benefit from better science regarding the utilization of waste materials in Portland cement concrete and asphalt pavement. This research will allow the industry and the regulatory community to better assess environmentally safe recycling of waste materials in the most cost efficient manner possible.

INFORMATION DISSEMINATION PLAN

Results of the project will be communicated to members of the solid waste community through two face to face project technical awareness group meetings. Quarterly project reports will be submitted to the Hinkley Center with updates on the project status. These reports will also be posted the project website along with routine updates on project results. A final report will be produced and disseminated to the project TAG as well as posted on the Hinkley Center and UF project websites.

TARGETED TECHNICAL AWARENESS GROUP MEMBERS

- Richard Tedder, Florida Department of Environmental Protection (Tallahassee)
- James Musselman, State Bituminous Engineer Florida Department of Transportation (Gainesville)
- John Power, Solid Waste Director Pasco County
- Lee Casey, Sr. Division Director Technical Services and Environmental Affairs Miami-Dade County
- Mark Wilfalk, Solid Waste Director - City of Tampa
- Kimberly Byer, Solid Waste Director - Hillsborough County
- Kelsi Oswald, Solid Waste Director – Pinellas County
- Mark Bruner, Solid Waste Director - Palm Beach County
- Dennis Davis, Jones Edmunds and Associates

PRINCIPAL INVESTIGATORS CONTACT INFORMATION

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