AASHTO
AASHTO INNOVATION INITIATIVE

AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. Sponsoring DOT (State): Missouri

2. Name and Title: Dave Ahlvers, State Construction and Materials Engineer

Organization: MoDOT

Street Address: 1617 Missouri Boulevard

City: Jefferson City

State: Missouri

Zip Code: 65109

Email: david.ahlvers@modot.mo.gov

Phone: 573-751-7455

Fax: 573-522-8416

Innovation Description (10 points)

The term "innovation" may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

Determination of Total Sulfur in Fly Ash by Sodium Carbonate Fusion

4. Please describe the innovation.

Sulfur in fly ash has become more prevalent due to Environmental Protection Agency regulations on the amount of sulfur dioxide (SO_2) gas emissions at coal-fired power plants. Utilities inject calcium into the

boiler causing a reduction of SO2 gases, but this results in more sulfur in the fly ash. Missouri Department of Transportation (MoDOT) has utilized the AASHTO standard for testing sulfur in fly ash and this method has worked for decades preceding EPA regulation. However, since the EPA regulations have changed the fly ash chemical characteristics, the AASHTO standard test method only tests for sulfate and not total sulfur. MoDOT's goal was to develop an alternate test method to measure total sulfur in fly ash by analytical methods.

5. What is the existing baseline practice that the innovation intends to replace/improve?

MoDOT's main objective was to devise a way of determining total sulfur in fly ash by moving away from the AASHTO standard. Through experience testing other materials, sodium carbonate was identified as a potential chemical component for this test. Sodium carbonate has been a good fusing agent or flux for other chemical test methods. When heated to higher temperatures, sodium carbonate encapsulates the fly ash so oxidation of the other forms of sulfur present can occur. Using this innovation simplified work and provided a measure of total sulfur as a sulfate.

6. What problems associated with the baseline practice does the innovation propose to solve?

The current AASHTO method would only test for one form of sulfur. The new method measures all forms of sulfur through fusion with sodium carbonate and oxidation. The benefits will create an innovative process improvement that enhances the overall work model. Quality control greatly improves as non-compliant material will be identified and eliminated as a potential threat to concrete as a sustainable product.

7. Briefly describe the history of its development.

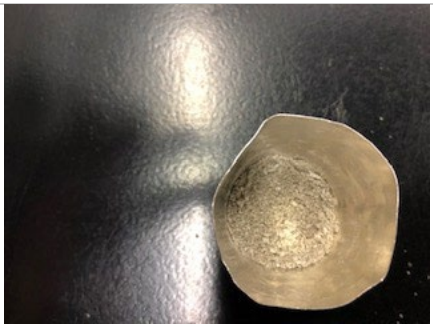
The project started in October 2020. Fly ash samples were submitted for testing and results were not indicative of the materials chemical composition. Initially, it was assumed results were due to operator error. The samples were re-tested with the same results. Further investigation concluded that the department's standard operating procedure (SOP) was not providing accurate test data. The decision was made to explore other testing options by bypassing the current SOP and creating an alternate test procedure. Through research and experience working with other materials, an internal test method was created that would enhance quality control. This new method was implemented in November 2020.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

MoDOT is an accredited Cement and Concrete Reference Laboratory (CCRL). To maintain accreditation, the department's laboratory is audited by an on-site inspection every two years. In addition, CCRL submits four samples annually to measure MoDOT's proficiency against other accredited CCRL

laboratories. Once testing is complete, results are submitted to CCRL and test results are compared to other laboratories results. A final report submitted by CCRL and each laboratory is graded on its proficiency. These CCRL samples are retained by each laboratory and used as quality control (QC) when testing other samples to measure competency and accuracy in testing. Past and present CCRL samples were used to qualify the new internal test method.

Attach photographs, diagrams, or other images here. If images are of larger resolution size, please provide as separate files.









Frame 1 shows the fly ash sample mixed with sodium carbonate. Frame 2 is a picture of the muffle furnace set at 1000 degrees Celsius in which the sample is placed for 30 minutes. Frame 3 is the fused sample. Frame 4 is a picture of the fused sample being dissolved in concentrated HCl. Frame 5 is ammonium hydroxide being added to the solution. Frame 6 is the sample converted to a base and the ferric (iron) hydroxides have precipitated out of solution. Frame 7 is the filter and filter funnel set-up to isolate the soluble to the non-soluble. Frame 8 is the ferric hydroxides caught in the filter. The beaker underneath catches the acid filtrate. Frame 9 shows the acid filtrate converted back to an acid using methyl red as an indicator and 10% barium chloride added to the solution. Barium sulfate is precipitated out, allowed to settle overnight and filtered to determine total sulfur as a sulfate.

State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The AII selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Prototype is fully functional and yet to be piloted

☐ Prototype has been piloted successfully in an operational environment

☐ Technology has been deployed multiple times in an operational environment

☒ Technology is ready for full-scale implementation

Test method was implemented November 2020

10. What additional development is necessary to enable implementation of the innovation for routine use?

All testing and qualification protocol has been successfully completed. No further research has been needed since inception.

11. Are other organizations using, currently developing, or have they shown interest in this innovation or of similar technology?? ☒ Yes ☐ No

The test method was submitted to the ASTM sub-committee chairman for his input and thoughts about pursuing as a national testing standard.

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
ASTM	Larry Sutter	XXX-XXX-XXXX	Larry Sutter <llsutter@mtu.edu>
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice.

12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?

High amounts of sulfur in concrete can cause delays in set times, affect compressive strength and durability and react with other constituents causing deleterious reactions and concrete failures. MoDOT can not only test materials accurately, but the process improvement saves money and assists the work process by providing timely results without delays or prolonging construction projects.

13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Safety	See below
Cost Savings	See below
Other (please describe)	See below

Provide any additional description, if necessary:

Improved safety: If MoDOT decided to purchase an expensive piece of instrumentation, such as an induction furnace, tanks of oxygen gas would be needed to run the instrument and offer potential hazards. If an X-ray fluorescence (XRF) would be purchased, high radiation exposure is possible and could cause health effects. **Cost savings:** The success of creating this test method eliminated the need to purchase new equipment (about $150,000), allowed in-house testing to be retained (savings of $125,000 annually) and continued the practice of recycling fly ash in concrete, which amounts to an average savings of approximately $2,275,000 per year. **Other (Improved Process and Increased Effectiveness):** These benefits fit into MoDOT's mission to pursue approaches to program delivery and project management that deliver the best possible value to Missouri taxpayers and to use existing resources wisely, always with an eye on the department's commitment to safety, service and stability.

14 How broadly might this innovation be deployed for other applications. in the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?

This method is not solely limited to fly ash but can be applied to other materials, such as cement, soil, aggregates and asphalt. Its versatility as a universal test method offers an inexpensive alternative so

contractors, consultants and DOT's can choose another option that greatly provides exceptional QC and accuracy.

Market Readiness (20 points)

The AII selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply	Dimensions	Please describe:
☐	Gaining executive leadership support	Click or tap here to enter text.
☒	Communicating benefits	The benefits are recurring and will not change over time.
☒	Overcoming funding constraints	This method does not require expensive equipment or reagents to perform test accurately. Testing can be performed in-house without the need to send to an independent laboratory, which affects cost and time savings
☒	Acquiring in-house capabilities	Most industry laboratories have the resources on hand to perform this method. No specialized glassware or reagents are required
☐	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	Click or tap here to enter text.
☒	Resolving conflicts with existing national/state regulations and standards	If conflicts arise, this method can be used as a suitable replacement or alternative to verify validation compared to other methodologies
☐	Other challenges	Click or tap here to enter text.

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: MoDOT saves money by performing all testing in-house. If MoDOT was unable to perform this method, the department would have to purchase an Induction furnace (approximately $50,000) or an XRF instrument (approximately $100,000). The other alternative would include sending samples to an independent laboratory ($250 per sample). Since MoDOT tests over 500 fly ash samples per year this would cost in excess of $125,000 on testing alone.

Level of Effort: This method can be performed by lab technicians, chemists, chemistry interns, etc. No level of higher education is required. Implementation of this procedure is advantageous to a testing facility wanting to implement this procedure since application can be adopted quickly.

Time: MoDOT saves time by performing the testing in-house rather than sending samples to an independent laboratory, which would delay construction projects and be detrimental to the effectiveness of the department's work model. Since the testing remains in-house, results can be relayed to construction inspectors quickly and efficiently.

17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

No expertise is required to implement this method. The testing can be performed by anyone who is properly trained.