MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-522 (project 683 | May 2024

Beneficial Reuse of Landfilled Fly Ash in Transportation Infrastructure

the ISSUE

Traditionally, unused fly ash is stored in landfills. However, there is significant potential to reclaim and repurpose these “off-spec” landfilled fly ashes (LFAs) through beneficiation (a process designed to improve physical or chemical properties), aligning with efforts to reduce the cement industry’s carbon footprint.

the RESEARCH

Landfilled fly ash was sampled from the Jim Bridger and Dave Johnson power plants in Wyoming and the Nucla station in Colorado. The chemical and physical properties of these LFAs in their as-received condition were evaluated, and those not conforming to ASTM C618 (the international standard for fly ash used in concrete) requirements underwent mechanical and thermal beneficiation, which involved grinding in a ball mill and exposure to high temperatures in a muffle furnace. A comprehensive set of experiments was conducted to assess the performance of mortars that combine ordinary Portland cement (OPC) and beneficiated LFA in terms of physical and chemical properties, reactivity, compressive strength, electrical resistivity, resistance to alkali-silica reaction-induced expansion, water absorption, and chloride permeation.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

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Project Title

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the FINDINGS

The research shows that thermo-mechanical beneficiation significantly impacts the physiochemical properties of landfilled fly ashes, resulting in reduced carbon content and increased fineness. X-ray diffraction analysis showed minimal changes in mineral composition post-beneficiation. LFAs, especially after beneficiation, exhibited improved reactivity as indicated by a strength activity index and modified R3 tests. Higher temperatures led to a notable reduction in LOI (a measure of unburned carbon), with implications for enhancing fly ash reactivity. Beneficiated LFAs performed well, achieving strength levels comparable to or exceeding OPC and ASTM compliant fly ash. LFAs exhibited evolving electrical resistivity, surpassing OPC after 56 days, suggesting microstructural improvements. LFAs, particularly samples from the Nucla station, demonstrated superior resistivity compared with FA, indicating improved microstructure. LFAs showed reduced chloride ingress, with Nucla surpassing ASTM compliant fly ash, highlighting enhanced resistance. LFAs effectively suppressed ASR-induced expansion and reduced water absorption rates, indicating enhanced durability potential and improved water penetration resistance.

the IMPACT

Research leading to the successful use of beneficiated LFA as a supplementary cementitious material in concrete offers notable environmental and industrial benefits. It can significantly reduce landfill waste by repurposing off-spec fly ash, thereby promoting sustainability in building materials. Additionally, LFA helps decrease reliance on dwindling traditional fly ash supplies, stabilizing the supply chain. Adopting LFA could cut greenhouse gas emissions from cement production by up to 10%, supporting global efforts to enhance sustainability and reduce environmental impacts in the building sector.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1171

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.