

Industry Assessment

Technical Brief

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Comparative Analysis of Steel Slags for Application in Cement and Concrete

Overview

Steel slag is a more durable alternative to traditional cementitious and aggregate materials. While ground granulated blast-furnace slag (GGBFS) has been extensively utilized as coarse aggregate and supplementary cementitious material (SCM), electric arc furnace oxidizing slag (EAFS) has lagged behind. Standard specifications which have facilitated the use of GGBFS, regulating product source and treatments to meet chemical and physical requirements for use in concrete and mortar, have not been finalized for EAFS. Without regulation of material acceptance, significant variability in product quality has raised concerns about leaching potential, alkali-silica reaction risks, and volumetric expansion owing to free lime and magnesium oxide content. EAFS must undergo source-specific stabilization methods before utilization, including pretreatment by carbonation, permanent wetting, and homogenization, with documentation to ascertain aggregate quality.

The flowchart in Figure 1 summarizes the utilization pathways of GGBFS and EAFS with respect to concrete.

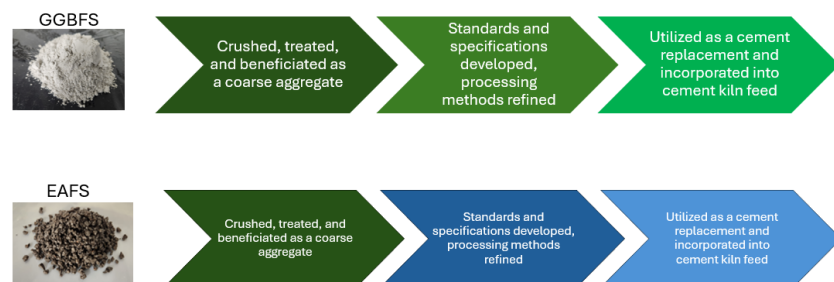


Figure 1: Evolution of GGBFS and EAFS applications in concrete. The green boxes for GGBFS indicate all stages of the process are complete, while stages 2 and 3 for EAFS (blue) are not complete/fully developed

USDOT Steel Slag Initiative

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Key Takeaways

- GGBFS is a common SCM, while EAFS is currently beneficiated as an aggregate.
- Research suggests EAFS could potentially see effective application as cement kiln feedstock or a cement replacement.
- While both GGBFS and EAFS have high potential for chloride exposure environments that require a denser matrix, long term EAFS performance has yet to be investigated.
- Development of standardized protocols for EAFS material qualification are necessary to account for source variability.

Source-Specific Processing

GGBFS is produced by rapid water-quenching of molten blast furnace slag and is subsequently processed by grinding into a fine powder to lock in the glassy structure and develop latent hydraulic reactivity in cementitious systems. Implementation is facilitated with standard specifications in ACI 233 and ASTM C989. EAFS requires additional processing relative to GGBFS to control volumetric instability due to expansive chemical compounds: free lime and magnesium oxide. Without standard specifications, industry processing techniques vary, including air-cooling, mist cooling, water quenching, and/or grading and stabilization procedures such as aging and carbonation.

Application

GGBFS sees the highest return on investment when beneficiated as a replacement for portland cement, with implementation facilitated by mature specification documents and robust and widely available service life models benefitting from long term durability data. Mitigation of deterioration mechanisms can be confirmed through testing in accordance with standard methods used in the portland cement industry. With denser and more angular aggregates, EAFS-aggregate concretes see the greatest return on investment concentrated in heavyweight/industrial (nuclear shielding, ballast, and industrial slabs) and mass-concrete applications. EAFS increases impact and abrasion resistance, and reduced heat of hydration benefits thermal control measures. Steel and synthetic fiber-reinforced EAFS concrete has shown potential for improved resistance to aggressive environments. EAFS has additional potential as a cementitious replacement, though further research is required to fully define its reactivity and effects on material properties.

This brief summarizes findings on Comparative Analysis of Steel Slags for Application in Cement and Concrete as part of the Industry Assessment for USDOT-SLAG, "Research Initiative on the Use of Steel Slag in Concrete and Cement" under cooperative agreement 693JK42550005. Information supporting these findings can be found at: <https://cait.rutgers.edu/usdotsteelslag/>. Inquiries about this work can be sent to: usdotsteelslaginitiative@rutgers.edu