

Industry Assessment

Technical Brief

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Properties and Performance of Electric Arc Furnace Slag in PC Concrete Applications

Overview

Steel slag is a byproduct of steel production in both the electric and blast furnace steelmaking systems. The blast furnace (BF) ironmaking process, a pre-requisite to the steelmaking basic oxygen furnace (BOF) process, generates ground granulated blast-furnace slag (GGBFS), which has been utilized as a coarse aggregate and supplementary cementitious material (SCM) in concrete for over a century. The electric arc furnace (EAF) process, however, has seen comparatively limited research into the applications of electric arc furnace slag (EAFS). Concrete with EAFS-aggregate is reported to have reduced workability, increased set time and density, and potentially improved strength and structural properties compared to concretes containing naturally mined aggregates such as limestone or granite. EAFS utilization is currently limited by source variability, volumetric expansion risks, and lack of long term durability data for developing service life models.

Key Takeaways

- EAFS may be an effective coarse aggregate replacement for concrete, but is not widely used at this time.
- Aggregate pretreatment systems are necessary to control volumetric expansion.
- Adjustments to mix design and curing practices are necessary to improve workability and set time impacts.
- Source variability requires stringent QA/QC, limiting investigation of potential use as an SCM.
- Data regarding long-term durability for developing service life models is lagging.

USDOT Steel Slag Initiative

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Pretreatment

EAFS aggregates require pretreatment to stabilize the expansive behavior (volumetric instability) of the material. Iron nodules and unreacted calcium and magnesium oxides in the slag are responsible for potential expansion, triggered by hydration reactions with water in both the short and long term. Suitable pretreatment methods to mitigate this effect include atmospheric weathering and aging and accelerated moistening/drying cycles.

Properties and Performance

EAFS particles are hard and dense with high angularity. These properties contribute to:

- Reduced slump in EAFS aggregate concretes, necessitating an adjustment to the water or paste content or the addition of super-plasticizing admixtures to restore workability.
- Increased density and ultrasonic pulse velocity.
- Decreased water absorption and porosity.
- Stronger cement paste-aggregate particle bonds and a denser interfacial transition zone (ITZ).
- Equivalent or improved compressive and tensile strength over natural aggregate concretes at replacement rates of 20 to 30%.

Source variability in EAFS generation and processing practices can contribute to variability in these properties and generate concerns about replicability of mixture properties. This variability has limited research into the potential for EAFS as an SCM as development of a sufficiently robust standard to address these concerns has been lagging.

Durability

Freeze/thaw performance has been shown to be similar to limestone or granite aggregate concrete, and reduced heat of hydration has shown favorable results for control against thermal cracking in mass concrete projects. However, EAFS concretes have shown increased carbonation depth, requiring additional consideration for durability and potential corrosion of structural concrete. Overall, evaluation has indicated that source-specific testing and qualification on aggregates, are essential to characterize material before use.

This brief summarizes findings on EAF Slag Performance in PC 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