

Industry Assessment

Technical Brief

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Geotechnical Characteristics and Applications of Steel Slag

Overview

Steel slag has been investigated as a viable alternative for various geotechnical applications, including its use as a replacement for traditional base materials in fill and granular columns, and as a pozzolanic binder for ground stabilization. The inherent physical and chemical properties of steel slag are generally conducive to direct implementation without the need for extensive post-production processing. When utilized in pozzolanic ground improvement, steel slag can offer significant financial savings compared to traditional binders. However, documented field applications remain limited, and current findings are primarily supported by laboratory-scale studies.

Key Takeaways

- Steel slag may serve as an effective and economically competitive alternative to traditional materials in granular columns, pozzolanic stabilization, and roadway construction.
- Slag aggregates exhibit high friction angles and unit weights relative to traditional geomaterials, though particle size distributions can vary significantly based on processing.
- Strength development for pozzolanic ground improvement is slower than conventional binders but can be accelerated with additives.
- Multiple opportunities exist for integrating steel slag into geotechnical applications without the necessity of extensive secondary processing or treatment.

Material Characteristics and Properties

Steel slag aggregates possess distinct physical and mechanical properties that make them suitable for geotechnical ground improvement. The material is characterized by highly angular particles with good interlocking, resulting in friction angles exceeding 40°. Due to a high specific gravity, the unit weights of steel slag are significantly higher than those of traditional mineral aggregates. The particle size distribution varies, ranging from silt/clay to gravel sizes depending on the specific production and processing methods employed. Furthermore, steel slag effectively improves the performance of

USDOT Steel Slag Initiative

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expansive soils by reducing the plasticity index and swelling potential; research indicates that free swell decreases nearly linearly with increased slag content

Pozzolan Ground Improvement

Steel slag may serve as a viable alternative to traditional binders like Portland cement. Research indicates strength development typically occurs slower than with cement or lime, though hydration often continues well beyond 28 days. Where higher early-age strength is required, chemical activators, such as quicklime or sodium silicate, can accelerate the process. While achieving performance parity may require larger volumetric portions of slag, the material remains effective in specialized applications; specifically, BOFS blended with lime can stabilize expansive clays to meet FHWA subgrade criteria and reduce swelling. Economically, one case study estimated cost savings of up to 46% over conventional materials. Long-term durability is supported by field data, including a steel slag subgrade in service for six years without reported issues.

Use in Aggregate Columns for Ground Improvement

Research on steel slag as a replacement for traditional aggregate column materials indicates the following:

- *Settlement and Consolidation:* Steel slag columns reduce embankment settlement compared to untreated ground, with geosynthetic encasement providing the greatest reductions. These columns also act as vertical drains, accelerating pore water pressure dissipation and shortening consolidation periods.
- *Mechanical Performance:* Slag columns often exhibit higher stiffness than traditional stone columns and significantly enhance the lateral capacity of native soil.
- *Design and Implementation:* A minimum diameter of 20 cm is required for significant gains in non-encased applications, though encasement is essential in soft ground. Currently, full-scale field performance and long-term implementation data remain limited.

Use as Roadway Fill and Aggregate Replacement

Steel slag may serve as a direct replacement for traditional fill materials in infrastructure construction due to its high friction angles and unit weights. However, the chemical composition of steel slag presents potential concerns regarding heavy metal leaching. Mitigation efforts may be necessary to ensure ongoing environmental compliance.

This brief summarizes findings on Geotechnical Use and Application of Steel Slag 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