

Industry Assessment

Technical Brief

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Office of the
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Steel Slag Aggregate in Asphalt Concrete

Overview

Steel slag aggregates (SSA), a by-product of steelmaking, have been extensively evaluated as substitutes for natural aggregates in asphalt concrete. The properties of SSA depend on the steelmaking process and furnace technology. In general, SSA used in asphalt concrete applications are valued for their hardness, abrasion resistance, and angular morphology. When locally sourced and properly processed, SSA can be cost-competitive with natural aggregates, driven by both performance improvements and resource considerations.

Key Takeaways

- The angularity, rough texture, and strength of SSA enhance asphalt concrete stiffness and aggregate interlock, which are beneficial for pavement performance.
- Post-production stabilization of SSA is required to prevent volume expansion due to free calcium and magnesium oxides.
- Asphalt concrete containing SSA generally shows improved mechanical and functional performance.
- SSA can be cost-competitive with natural aggregates when locally sourced, with environmental impacts determined by leaching behavior and material encapsulation in asphalt.

Design Consideration

The primary risk associated with SSA in asphalt concrete is volumetric expansion due to the hydration of unreacted free calcium and magnesium oxides if SSA is not adequately stabilized prior to use. To mitigate this risk, SSA must undergo post-production stabilization (outdoor stockpiling and weathering for several months or accelerated aging treatments evaluated through expansion testing). The rough and porous surface of SSA increases binder absorption and demand, requiring careful design of the optimal binder content to prevent bleeding or mixture instability. As steel slag is denser than natural aggregate, the weight-based gradation can lead to unintended changes in air voids and mixture volumetrics if not properly accounted for.

USDOT Steel Slag Initiative

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Performance of Asphalt Concrete with SSA

- Research indicates that asphalt concrete amended with SSA generally exhibits equal or improved mechanical performance after weathering stabilization when compared to traditional asphalt concrete, including its stiffness, rutting resistance, fatigue performance, and low-temperature cracking resistance.
- In field applications, asphalt pavement with SSA demonstrates surface texture retention and skid resistance over time (due to high hardness and resistance of SSA to aggregate polishing), enhanced rutting resistance, and maintains good smoothness in limited applications.
- Performance improvements are most pronounced when SSA replaces the coarse aggregate fractions in asphalt concrete.
- At high SSA contents, particularly when slag fines are high, excessive stiffening can increase brittleness if the mix design is not properly proportioned.
- Reported aggregate replacement levels range from 20% to 100%, depending on slag type and mixture design.
- Aggregate replacement up to 75% provides the best balance between stiffness, rutting resistance, and cracking performance.

Regulatory & Implementation

The suitability of SSA for road construction is predicated on achieving volume stability and environmental compliance. However, formal regulatory acceptance is currently fragmented and often determined on a case-by-case basis. When properly processed and stabilized, SSA generally meet established leaching limits, with heavy metal release typically within regulatory thresholds as verified by standardized tests. Incorporation into asphalt concrete further suppresses leaching, as asphalt encapsulation limits water contact and exposure pathways. Existing standards (e.g., ASTM D5106, ASTM D4792) provide frameworks for approving SSA in asphalt concrete applications, requiring expansion testing, and, where applicable, environmental risk. Life-cycle cost analysis and environmental assessment of SSA use in asphalt concrete is recommended.

This brief summarizes findings on Steel Slag Aggregate in Asphalt 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/publications/>. Inquiries about this work can be sent to: usdotsteelslaginitiative@rutgers.edu