

Slag Utilization in Concrete and Asphalt at Nucor Steel Auburn, Inc. Partnering with New York State Department of Environmental Conservation (NYSDEC) Pollution Prevention Institute (P2I) , Clarkson University and Rochester Institute of Technology.

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Future of Slag in New York State

Regulatory and technical challenges faced by Nucor Steel Auburn, Inc.

- Regulatory history of slag at Nucor Steel Auburn, Inc.
- Future regulatory challenges
- Partnering with Pollution Prevention Institute (P2I) and Clarkson University on Slag Technical Evaluation
- Low-Embodied Carbon Concrete
- Producing 67 stone and #9 aggregate

History of Slag at Nucor Steel Auburn, Inc.

- Beneficial Use Determination (BUD) since 1994
 - 2010 renewal
 - NYSDEC modifies BUD to only allow for encapsulated end uses
 - Following a presentation of technical data and threats of legal action, NYSDEC re-authorizes historic uses
 - 2017 Solid Waste Rule Changes (Part 360)
 - New regulations would require slag to meet Part 375 soil cleanup objectives
 - *The unrestricted use soil cleanup objectives represent the concentration of a contaminant in soil which, when achieved at a site, will require no use restrictions on the site for the protection of public health, groundwater and ecological resources due to the presence of contaminants in the soil.*
 - Nucor and NYSDEC enter Memorandum of Understanding (MOU), BUD will not be modified for 5 years, or until appropriate technical evaluation has been completed
 - **2022 BUD and MOU renewal**

Future regulatory challenges

- US EPA and National Academies of Sciences, Engineering, and Medicine (NASEM) health risk assessment
 - The Committee will conduct a review of existing information and analyses related to electric arc furnace (EAF) slag and assess human health risks associated with the unencapsulated use of EAF slag.
 - <https://www.nationalacademies.org/our-work/electric-arc-furnace-slag-understanding-human-health-risks-from-unencapsulated-uses>
- NASEM study is being closely monitored by NYSDEC
 - NYSDEC is pursuing an update to our MOU to include language referencing this study.

Slag Technical Evaluation

- Pollution Prevention Institute (P2I) at Rochester Institute of Technology
 - NYSDEC funded program
 - Original scope of study proposed by NYSDEC focused on process changes to remove “tramp” metals
 - 2020 scope finalized
 - Provide an independent, third-party assessment, this project will evaluate the feasibility of EAF slag as a replacement for course aggregate in concrete, in a lab environment, in accordance with ASTM industry test standards.

Slag Technical Evaluation

Nucor Steel Auburn, Inc. (Nucor) has requested assistance from the New York State Pollution Prevention Institute (NYSP2I) at Rochester Institute of Technology (RIT) to conduct a feasibility study of electric arc furnace (EAF) slag as a replacement for coarse aggregate in concrete. NYSP2I will partner with Clarkson University (Clarkson) to conduct the feasibility study in accordance to ASTM standards.

The feasibility study will include measurements of the following:

1. The physical properties of EAF slag coarse aggregates
2. The influence of EAF slag coarse aggregate on the workability of fresh concrete
3. The influence of EAF slag coarse aggregate on the compressive strength of concrete
4. The expansion of concrete containing EAF slag coarse aggregate, and,
5. Estimation of the maximum feasible percentage of EAF slag coarse aggregate in concrete.

Low-Embodied Carbon Concrete

- Bill S542A signed into law December 2021. Executive Order 4 (EO4) Approved Specification for Lower Carbon Concrete
 - Goal
 - To inform through this guidance document how Design Professionals (Architects or Engineers of Record) specify concrete, in a way that builds upon current market capabilities, practices, and available materials, so that we dramatically reduce the embodied carbon burden of the entire building industry.
 - Background
 - To achieve the GHG reduction goals of the Climate Leadership and Community Protection Act the State needs to reduce the embodied carbon in our built environment. Concrete includes use of cement, which yields approximately 0.9 pounds of carbon emission equivalents (CO₂e) for each pound of cement produced.

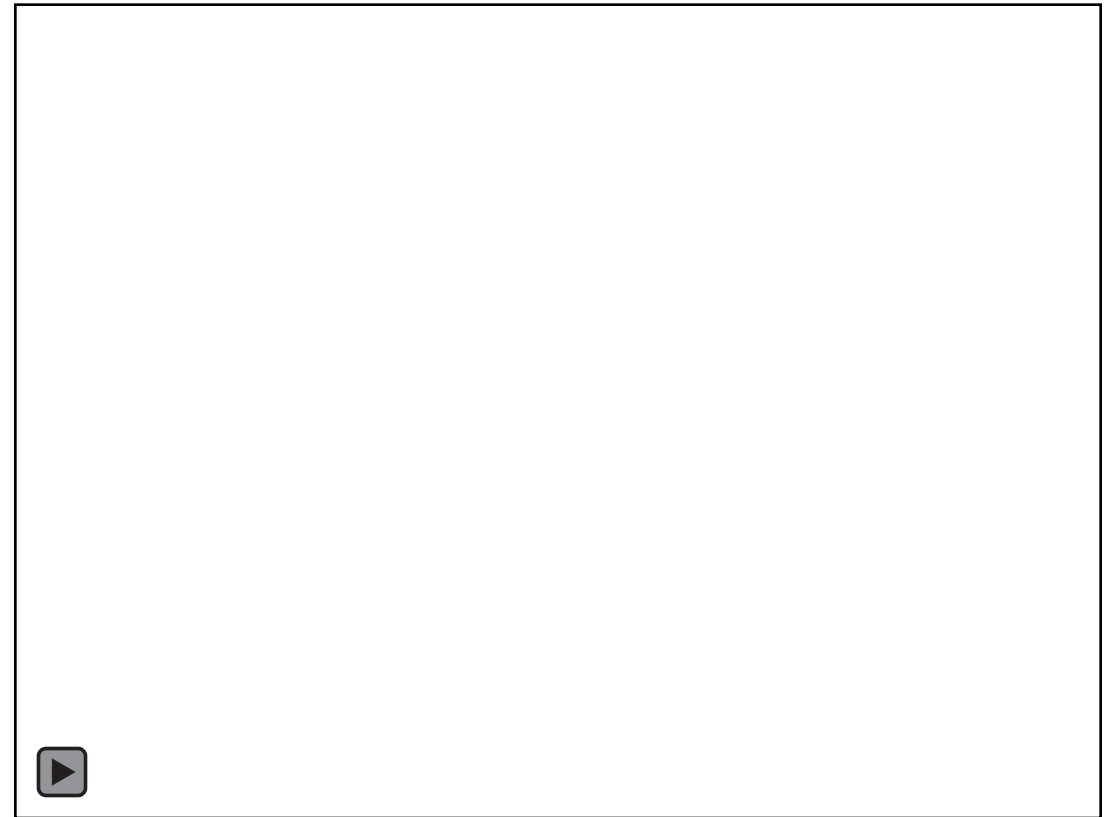
Where does slag fit in with Low-Embodied Carbon Concrete?

- EAF slag as low carbon aggregate alternative
 - In-line with P2I technical evaluation
 - Supports NYSDEC agenda for encapsulation of slag
 - Creates demand for slag in a growing market
- Environmental Product Declaration (EPD) for slag
 - Instances where no EPD is available: 0.0210 CO₂ per unit lb. vs Virgin Coarse Aggregate 0.0459 CO₂ per unit lb.
 - Slag CO₂ value based on blast furnace data
 - EPD developed by NSA and Nucor Steel Auburn, Inc. will provide lower, more accurate CO₂ values.

Producing 67 Stone

In October 2021, TMS and Nucor trialed a new slag plant to produce 67 stone.

- 60% material conformed to 67 stone requirements
- Lab and 3-yd batch testing shows EAF slag can replace up to 25% #1 limestone
- Potential for remaining material to meet #9 aggregate for asphalt



Slag as 67 Stone

- Positive Attributes:
 - Material Hardness – adding to compressive strength
 - Lack of #200 Sieve Component – contributes to paste bond
 - Angularity/Porosity – Contributes to paste bond
 - Consistent physical chemistry compared to natural aggregate (i.e. specific gravity)
 - Decrease in virgin aggregate use
 - Supports NYSDEC agenda for encapsulation of slag
- Things to Consider:
 - Increased Porosity – mix designs require additional water
 - Increased Density – mix design unit weight
 - Cost of new slag processing plant – initial estimates ~\$1 million
 - Making a consistent material that meets 67 stone and #9 aggregate
 - DOT approval for 67 stone

Summary

- Regulatory challenges will continue for EAF slag
 - NYSDEC and P2I Study
 - USEPA Health Risk Assessment
- The green economy can create opportunities for slag
 - Low-embodied carbon concrete
 - #9 aggregate in asphalt

Questions?