Long Term Performance Monitoring of Steel Slags in Granular Roadways

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Introduction

- Application of recycled aggregates in granular roadways
  - Comparable or superior mechanical properties
  - Supports sustainable development
- Steel slag: A promising recycled material for civil engineering

Steel Slag Roadways

- Long-term performance commonly evaluated under accelerated ageing in laboratories

FIELD CONDITIONS UNREPLICABLE + PRESENCE OF HYDRATION PRODUCTS AND CARBONATES + ENVIRONMENTAL CONCERNS → Necessitate → LONGTERM MONITORING UNDER FIELD CONDITIONS

Goal and Objectives

"To assess the long-term mechanical performance and environmental impacts of steel slag as an aggregate material in granular roadway applications."

Select Location:
Constructed over seven years ago
Howard County, IA

IOWA

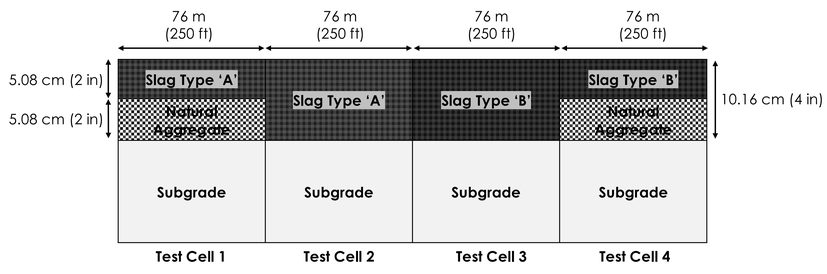
Evaluate Mechanical Performance

Environmental Impact Analysis

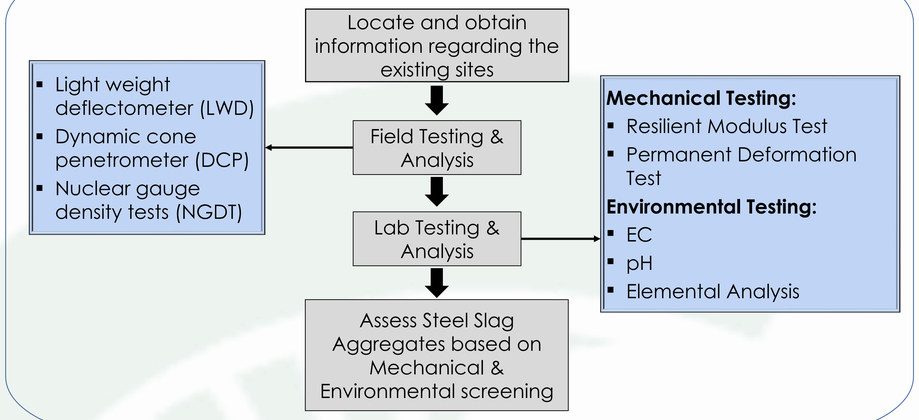
Demonstrate Steel Slag as a Sustainable Alternative

Test Sections

- 4 x Test sections constructed in 2018.



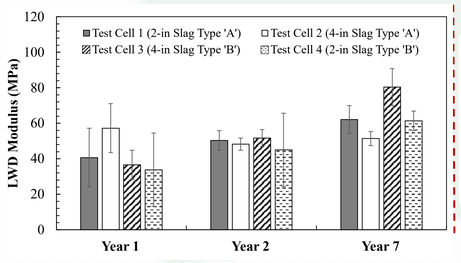
Methodology



Mechanical Test Results

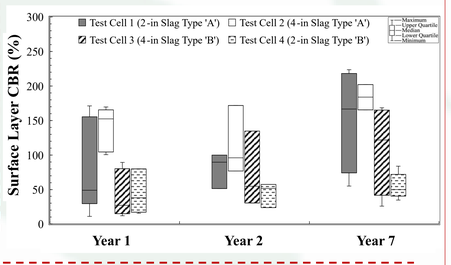
Light Weight Deflectometer Tests

- **Increase in stiffness** due to the development of hydration products
- Moduli remained **within acceptable range** (2)



Dynamic Cone Penetrometer Tests

- Significant increase in California Bearing Ratio (CBR), indicating **improved strength and compaction**

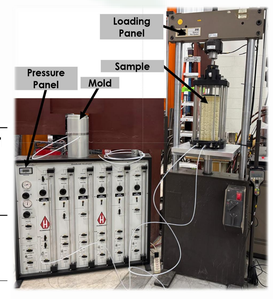


Resilient Modulus and Permanent Deformation Tests

- Resilient modulus and permanent deformation **values within or higher than typical Iowa gravel materials'** range (3)

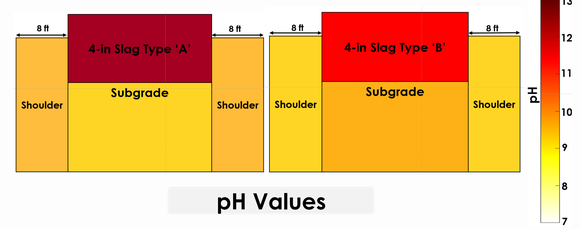
Materials	k_1	k_2	k_3	R^2	SM_R (MPa)	Permanent Strain (%)
Steel Slag Type '**A**'	1636	0.45	-0.08	0.95	**221.6**	**0.12**
Steel Slag Type '**B**'	1107.7	0.54	-0.09	0.90	**159.5**	**0.07**

k_1, k_2, and k_3 = regression coefficient; SM_R = Summary resilient modulus

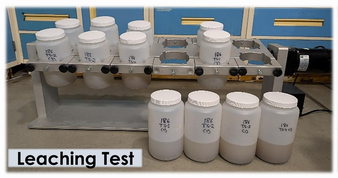


Environmental Test Results

- High **pH** at surface layers, but carbonate layers formed in the field (disrupted in lab) limit leaching of hydroxyl ions, resulting in **lower pH in surrounding soils**



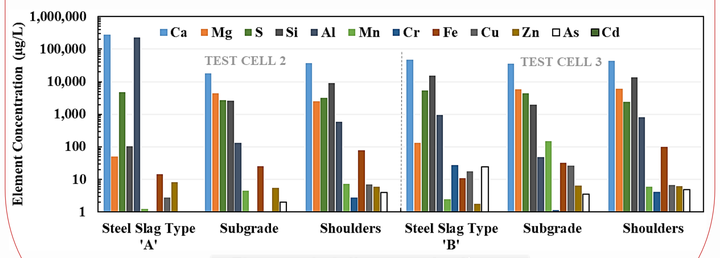
pH Values



Leaching Test

ICPMS Equipment

- **Elemental Analysis:** All elements **within USEPA limits** (4)



Elemental Concentrations

Conclusions

- Both steel slag types showed **increasing stiffness** due to **hydration and carbonation**.
- Both types **met or exceeded natural aggregate stiffness values**.
- 2-inch layers performed comparably to 4-inch layers, allowing for design optimization.
- Field **carbonation stabilized toxic elements**, reducing leaching risks within acceptable limits.
- **Laboratory tests showed higher pH and metal concentrations** due to disruption of carbonate layers, **unlike in real field conditions**.

Acknowledgements
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References
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