SUSTAINABLE STABILIZATION OF SUBGRADE SOILS IN KAZAKHSTAN USING CONVERTER SLAG BASED ON INDUSTRIAL WASTE

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PROJECT OBJECTIVES

Use BOF slagto strengthen Kazakhstan's subgrade soils, improve durability, and cut CO_2 emissions and costs.

SCIENTIFIC NOVELTY

First comprehensive study in Kazakhstan evaluating BOF slag for stabilizing a range of subgrade soils.

BOF SLAG

Figure 1 – Distribution of BOF slag in Kazakhstan

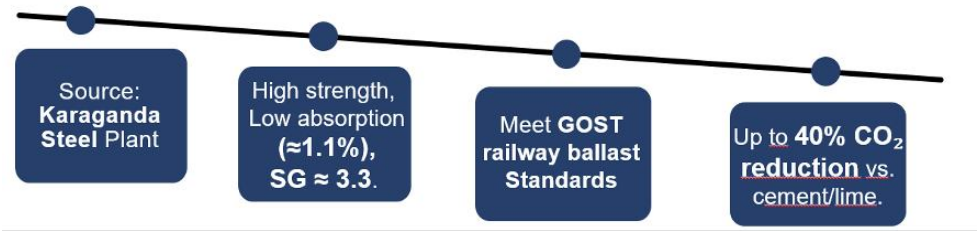


Figure 2 – Key characteristics and advantages of BOF slag from the Karaganda Steel Plant

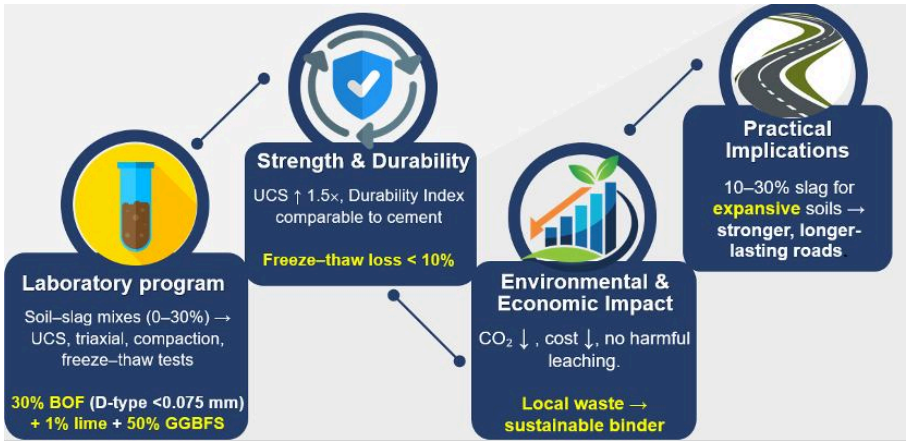


Figure 3 – Application of BOF in Soil Improvement

ENVIRONMENTAL & ECONOMIC IMPACT

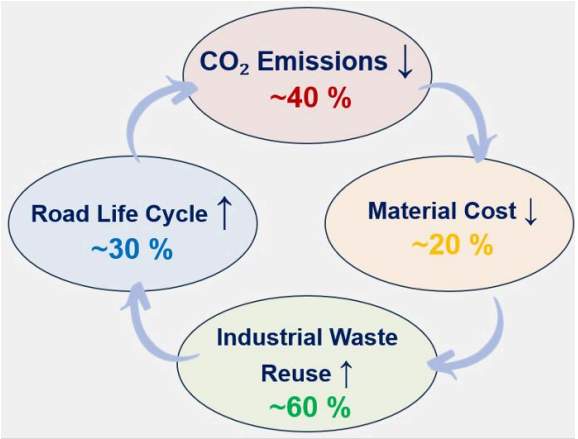
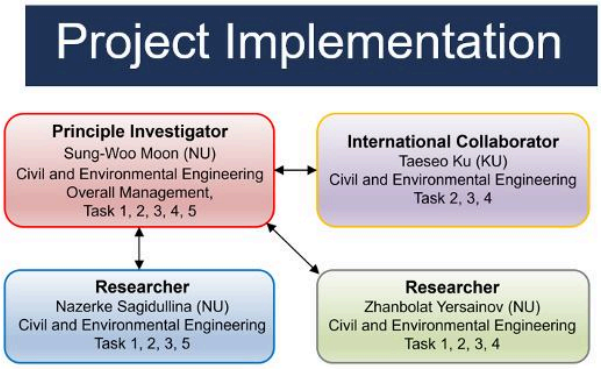


Figure 4 - Environmental and economic impact of BOF slag in road construction

Figure 5 – Project implementation framework integrating laboratory testing and ANN/ML-based modeling

RESEARCH TEAM & PLAN



Research Activities	2026				2027				2028				Work Distribution	
Task	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	NU	KU
Task 1: Soil Characterization													10	0
Task 2: BOF slag treatment													25	4
Task 3: Strength and Durability Testing													25	4
Task 4: ANN/ML/Numerical Simulation													7	20
Task 5: Engineering Recommendations													5	0
Sub total													72	28
Total													100	

Figure 6 – Project implementation structure, roles, and timeline

PROJECT IMPLEMENTATION

- R&D results
  - Laboratory database covering geotechnical, durability, and microstructural properties.
  - Numerical models linking BOF slag content to performance, including ANN/ML predictive tools.
  - Preparation of at least 2 Q1–Q2 journal articles and conference presentations.
  - Draft design charts and technical documentation for implementation.

TIME FRAME AND BUDGET

- **Duration:** 36 months (2026–2028)
- **Budget:** $150,000-200,000 USD

PI'S PREVIOUS APPLICATIONS (BOF)

For soil stabilization

- Mustafayeva, A., Moon, S.W*., Satyanaga, A., Kim, J., (2024) "Enhancing Mechanical Properties of Expansive Soil through BOF Slag Stabilization: A Sustainable Alternative to Conventional Methods", Minerals, 14(11), 1145 (Q2, SCOPUS Percentile 74%)
- Mustafayeva, A., Bimykova, A., Olagunju, S., Kim, J., Satyanaga, A., Moon, S.W*. (2023) Mechanical properties and microscopic mechanism of basic oxygen furnace slag-based stabilized clay, Buildings, 13(12), 2962 (Q1, SCOUPS Percentile 84%)
- Abishev, R., Satyanaga, A*., Kim, J., Shon, C., Rahardjo, H., Qian, Z., Moon, S.W., (2024) Stability of soil slope in Almaty covered with steel slag under the effect of rainfall, Scientific Report, 14, 7711 (Q1, SCOUPS Percentile 92%)
- Mustafayeva, A., Bimykova, A., Kim, J., Moon, S.W*., (2023) "Soil stabilization with Basic Oxygen Furnace (BOF) Slag", 17th Asian Regional Conference (A.R.C.) on Soil Mechanics and Geotechnical Engineering, Aug 14-18, 2023, Nur-Sultan, Kazakhstan.

For railway ballast materials

- Olagunju, S., Mukhtarkhan, D., Kim, J., Satyanaga, A., Moon, S.W*. (2023) Physical, mechanical, chemical, and environmental characterization of stockpiled BOF slag as railway ballast material, Construction and Building Materials, 408, 133613 (Q1, SCOUPS Percentile 96%)
- Koh, T*., Moon, S.W., Jeong, H, Jeong, Y., Pyo, S. (2018) A Feasibility Study on the Application of Basic Oxygen Furnace (BOF) Steel Slag for Railway Ballast Material, Sustainability, 10(2), 284 (Q1, SCOUPS Percentile 90%)
- Olagunju, S., Suleimen, Z., Muratova, A., Mukhtarkhan. D., Darbayeva, T., Kim, J., Moon, S.W*., (2023) "Characterization of basic oxygen furnace (BOF) slag for railway ballast material", 17th Asian Regional Conference (A.R.C.) on Soil Mechanics and Geotechnical Engineering, Aug 14-18, 2023, Nur-Sultan, Kazakhstan.

Figure 7 – Circular solution for BOF slag utilization in sustainable road construction

This study demonstrates that Basic Oxygen Furnace (BOF) slag is an effective and sustainable material for stabilizing subgrade soils and slopes in Kazakhstan. The results confirm significant improvements in strength, durability, and resistance to rainfall and freeze–thaw cycles, while reducing CO_2 emissions, material costs, and landfill disposal. Utilizing locally available industrial waste supports a circular economy approach and provides a viable pathway toward stronger, climate-resilient, and carbon-neutral road infrastructure beyond 2030.