Using Natural Cementation Systems to Control Corrosive Dust on Un-surfaced Roads

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Army Training Areas Can Be Subject to Problems of Dust

- Unsurfaced roads and unsurfaced landing zones are major problems in arid terrain
- Dust introduces abrasives into the vehicle systems and clogs air filters
- Dust control agents are frequently inorganic salts, chlorides that can produce additional corrosion problems
- Conventional paving is not practical
Alkali-based Silicate Cements—An Alternate Solution

- Alkali-based silicate (ABS) cements are special cements formed by mixing a concentrated alkali solution with a finely ground reactive silicate or aluminum silicate.
- ABS cements are strong, fast-setting, inexpensive to make and very versatile.
- Manufactured from glassy silicates (typically metallurgical slags), volcanic glass, fly ash and low-fired clays.
- Can use waste alkali from manufacturing operations.
- No Portland cement is involved.

Soil solidified with alkali-activated glass slag.
Pohakuloa Training Area (PTA) as a Test Site

- Serious dust problem at site
- Soil is abrasive, corrosive dust
- Soil is largely volcanic glass and should be reactive
- Cementation should be more durable than any type of dust palliative

Typical stretch of Access Road at PTA
PTA Access Road
Suitability of PTA Site

- Serious dust problem
- Little relief
- No drainage problems
- Moderate traffic
- Access available for alkali-activation treatment

PTA Access Road
Untreated Soil—Weathered Lava Glass

- Mostly glassy, easily reacted with alkali
- Very little crystalline material
- Sharp edges, and corners
- Wide range of grain sizes

Photomicrograph of Soil
X-Ray Diffraction Pattern for PTA Soils

Single crystalline phase present— the feldspar Anorthite

\[ \text{Na}_{0.05}\text{Ca}_{0.95}\text{Al}_{1.95}\text{Si}_{2.05}\text{O}_8 \]
How is Alkali-activated Glass Different from Conventional Cement?

• Glass can be both the aggregate and form the cementing phase
• Waste glass (slag, fly ash) can be used
• More alkaline solution is used to form the bonding gel and other phases
• Strength can be comparable to Portland cement mortar
Why Use Alkali-treatment?

• Fast: Mixture sets in hours and gets ultimate strength in days

• Easy to Obtain Materials: Suitable raw materials are available almost everywhere (fly ash, slag, calcined clays)

• Economical: Uses waste materials or low-fired clay soils

• Versatile: Basic chemistry adapts from a wide variety of glassy materials – even volcanic glass

• Variation of natural weathering process that occurs in volcanic ash deposits
Initial Treatment with Alkali

- Alkali attacks edges and corners of coarse grained materials
- Fines can react completely
- Silica gel that forms has form similar to CSH phase
- Secondary minerals (zeolites) contribute to cementation
Alkali-activation Treatment of Unpaved Roads

- Widely used in Australia
- Marketed by Blue Circle Cement Company
- Reported to use Na-rich kiln dust
- Broad range of compositions

Roadment® application
Comparison of Alkali-activation and PC addition

Compressive strength vs. Curing time for different mineral activators
(with 6% Na$_2$CO$_3$ in binder)

Can we do better with glassy PTA soil?
Initial Mix Development

- First trials have produced moderate early strengths
- 28-day strength should be comparable to or better than published results
- Work is continuing using local fly-ash as secondary silica source
- No significant technical barriers have been encountered

Test cylinder with sodium carbonate activation
Future Work

• Structure-Property Characterization
  – Compressive strength
  – Nanoindentation
    • Modulus and hardness of transition zones
  – SEM with WDS
    • Chemical analysis
    • Fracture surface characterization
• PTA road stabilization
  – Transition from laboratory to field
SUMMARY

• Control of abrasive dust is a serious corrosion and equipment maintenance issue

• Alkali-activated cementation has been used for glassy materials containing glassy silicates

• Reports in the literature indicate it should work on unpaved roads

• Experience from Australian full-scale road stabilization indicates no technical barriers

• Initial lab results were successful

• Planning for conducting and evaluating stabilization program at PTA is proceeding
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Questions
Why Hasn’t ABS Cement Taken Over the Market?

- It is NOT Portland cement!
- No one writes specs for use of non-PC concrete
- Requires phosphate or borate retarders – products used to regulate set with PC will not necessarily work with alkali-based silicates
- Handling and placing characteristics are slightly different-- uses more vibration-- uses minimum water

Si-O-Al-O-Si bond
Alkali-slag Patching Material