

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



Soil solidified with alkali-activated glass slag

- **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**



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**

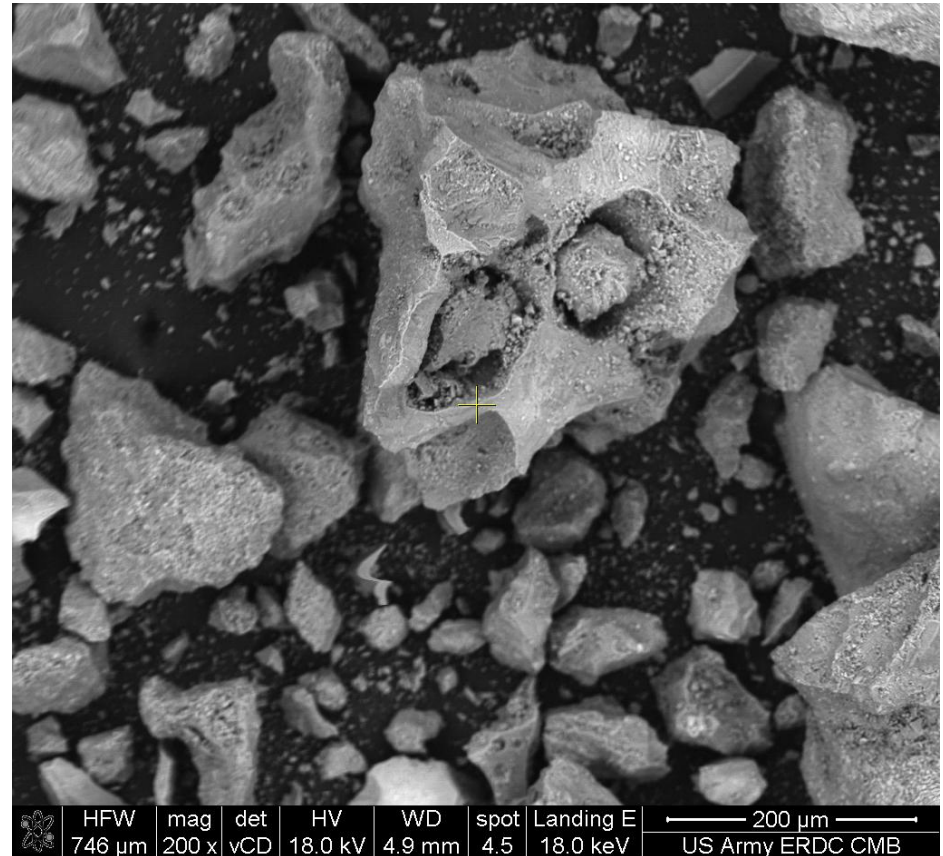


PTA Access Road



Untreated Soil—Weathered Lava Glass

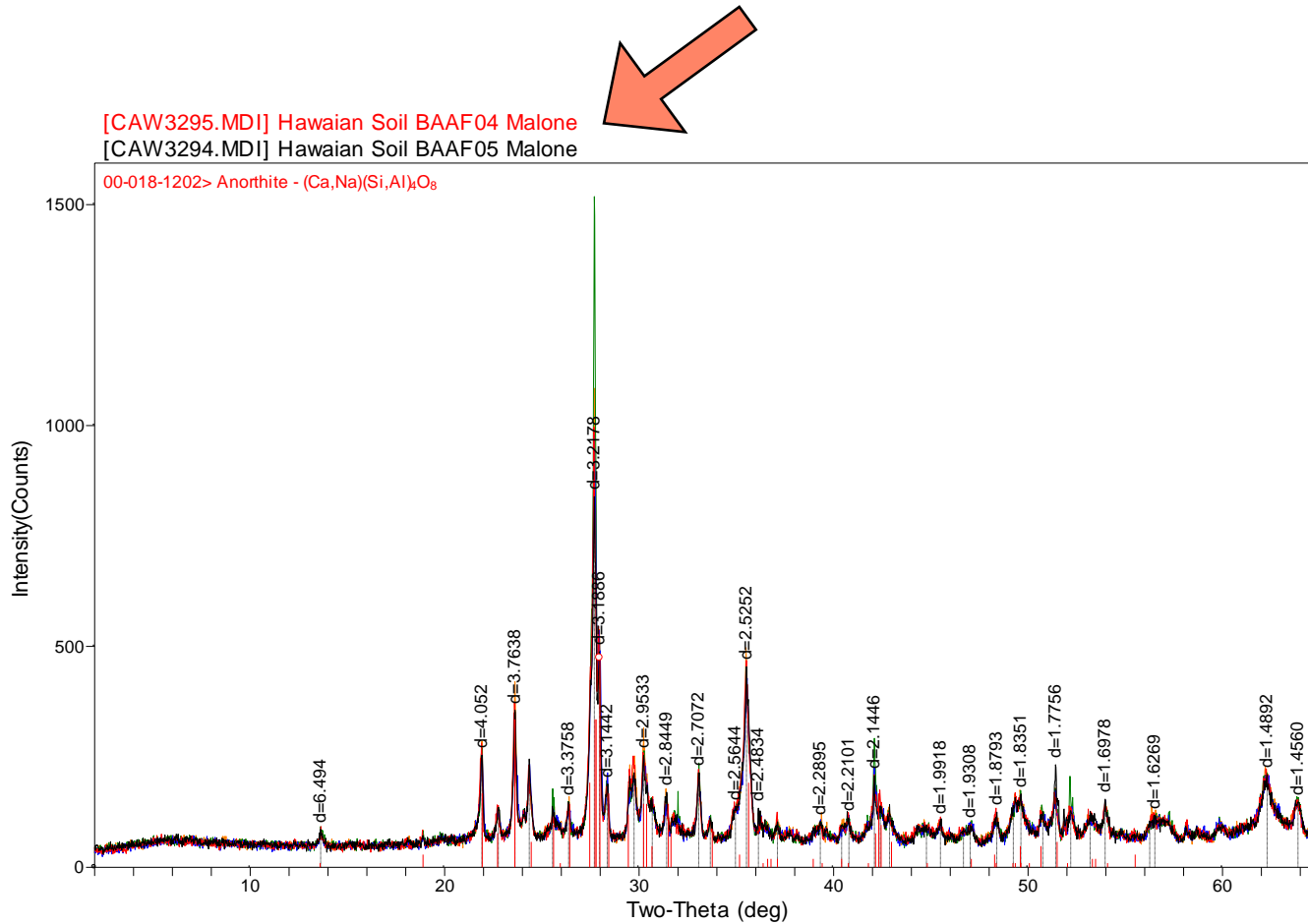
- Mostly glassy, easily reacted with alkali
- Very little crystalline material
- Sharp edges, and corners
- Wide range of grain sizes



Photomicrograph of Soil



X-Ray Diffraction Pattern for PTA Soils

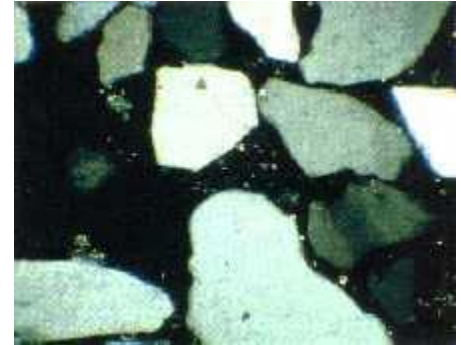


Single crystalline phase present— the feldspar Anorthite

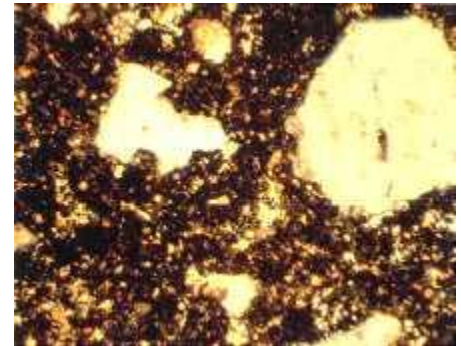


How is Alkali-activated Glass Different from Conventional Cement?

- **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**



Alkali- activation of glass



Conventional cementation

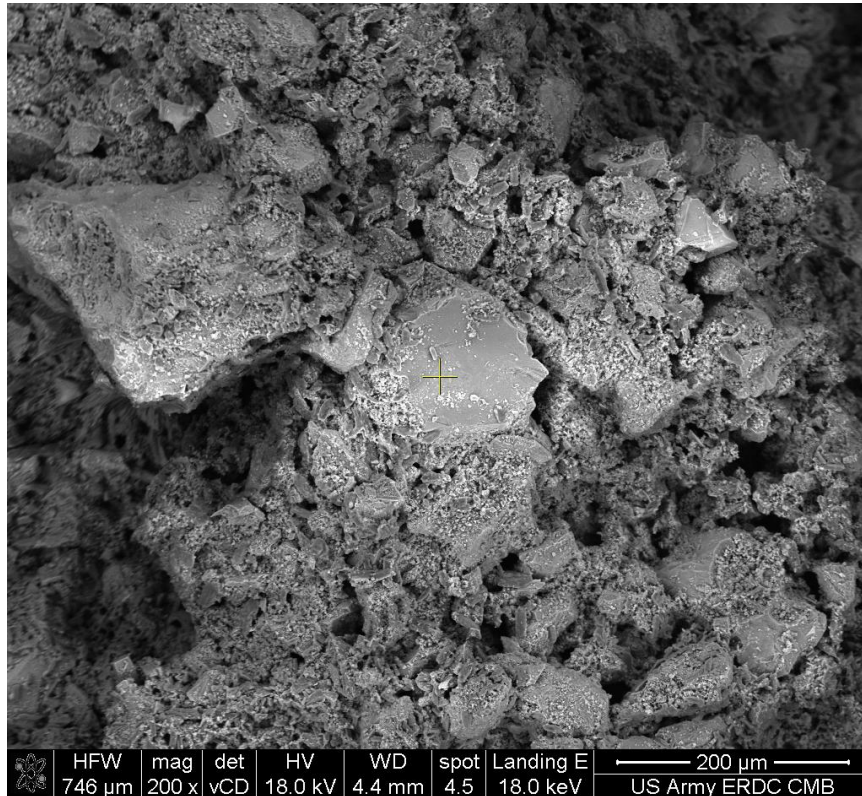


Why Use Alkali-treatment?

- **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



PTA soil after alkali treatment

- 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

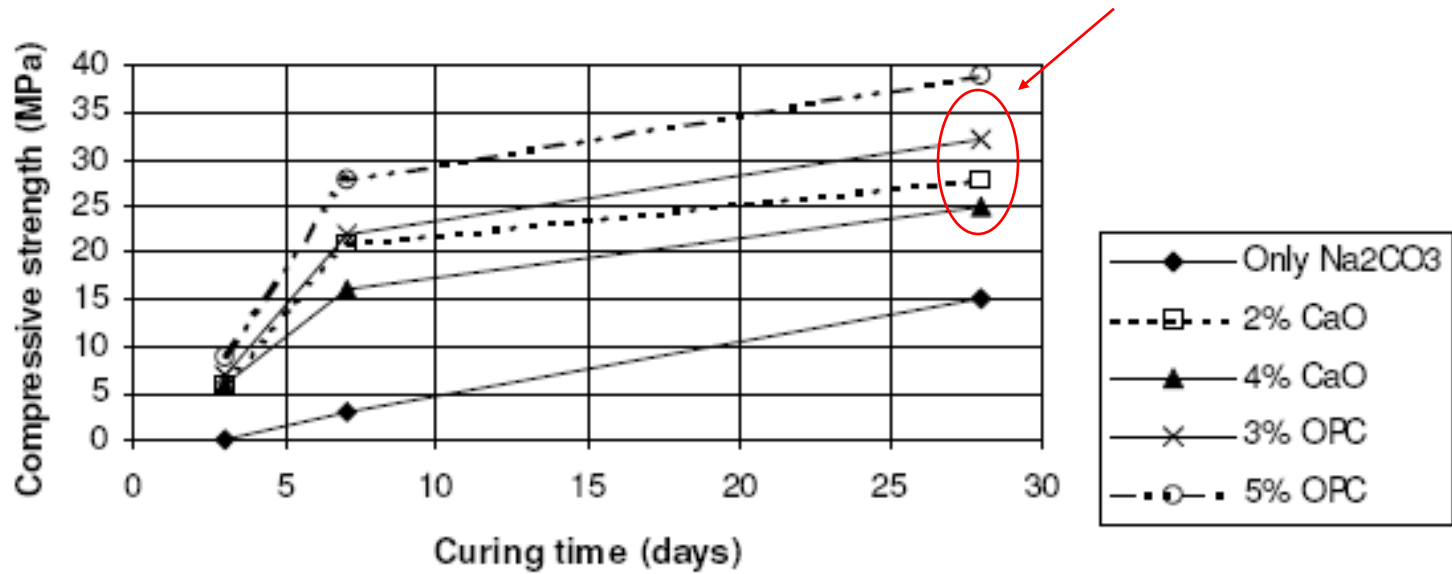
- **Widely used in Australia**
- **Marketed by Blue Circle Cement Company**
- **Reported to use Na-rich kiln dust**
- **Broad range of compositions**



Roadment® application



Comparison of Alkali-activation and PC addition



*Compressive strength vs. Curing time for different mineral activators
(with 6% Na₂CO₃ in binder)*

Can we do better with glassy PTA soil?



Initial Mix Development

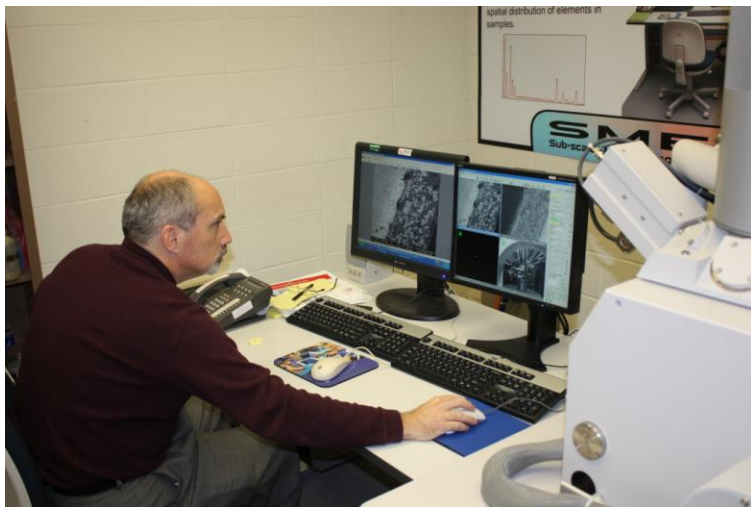
- First trials have produced moderate early strengths
- 28-day strength should be comparable to or better than published results
- Work is continuing using local fly-ash as secondary silica source
- No significant technical barriers have been encountered



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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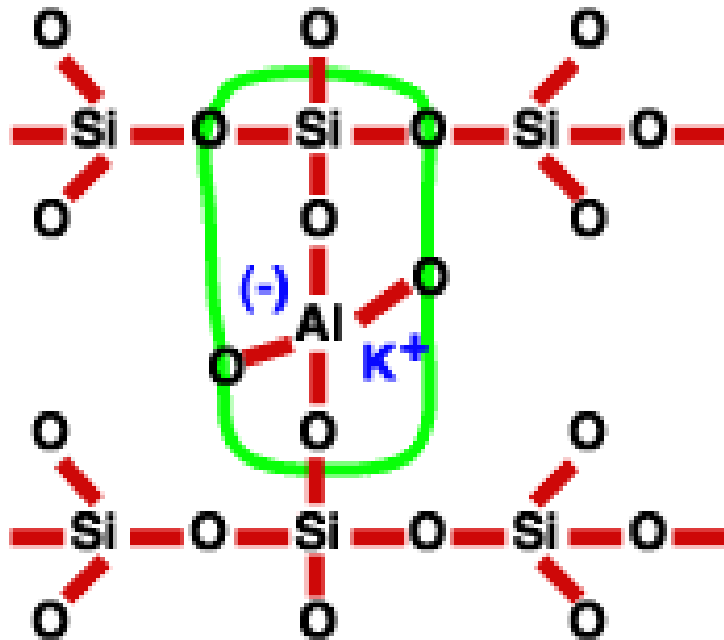
F10AR06 Accelerating Natural Cementation for Road Stabilization



Questions



Why Hasn't ABS Cement Taken Over the Market?



Si-O-Al-O-Si bond

- 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



Alkali-slag Patching Material

