Basic Crystalline Material Durability

Izak Breytenbach
Introduction

• Basic crystalline materials commonly used for road construction aggregate in South Africa
• Dolerite, basalt, diabase...but also amphibolite, andesite, anorthosite, diorite, gabbro, greenschist, norite, peridotite, phonolite, serpentinite.
• Used for road construction: dolerite, basalt, diabase, andesite, amphibolite, diorite, gabbro and norite.

Question: If we know it is problematic, why do we use it?
Answer: Distribution and lack of alternatives.
Introduction
Durability Issues: New Problem?

• Dolerite durability problems have been researched in past decades (e.g. Clauss, 1967; Orr, 1979; Weinert 1964; Weinert, 1980; etc.)

• Basalt durability assessed during Lesotho Highland Water Scheme (Van Rooy and Nixon, 1990; Van Rooy, 1991; Van Rooy and Van Schalkwyk, 1993; etc.)

• More recent research, specifically related to road construction aggregate (Bell and Jermy, 2000; Paige Green, 2007; Leyland et al, 2013; Leyland et al, 2014)

• New COTO?
What is the problem?

• Seemingly competent/sound/hard rock completely deteriorates in service or during quarrying/production
• Durability problems see two main changes (Leyland, 2014):
  • The production of more fines during construction
  • An increase in plasticity index and linear shrinkage of fines
• Mechanism: Active clay minerals in the rock material which originate from mineral weathering becomes liberated/activated, usually when exposed to atmospheric conditions (i.e. quarrying and construction)
What is the problem?
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Photograph by R.C. Leyland
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Is durability always the problem?

• Definitely not!
• Section 3602 (a) of COLTO (1998) for aggregate:
  • “...It shall not contain any deleterious material such as weathered rock, clay, shale or mica...”
• Consider the geological origin of dolerite/basalt: mostly intrudes through country rock (e.g. sandstone, shale, tillite, etc.)
• Materials are often contaminated by assimilated sedimentary rock originating from the country rock (i.e. xenoliths)
• Know your geology!
Is the problem always durability?
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What to do?

• Investigate thoroughly:
  • Invasive drilling investigations
    • SAPEM Chapter 8: “The depth and spacing of boreholes will be dependent on the nature of the rock source being investigated. However it is recommended that boreholes should be spaced no greater than 30 metres apart and be drilled to a depth at least 5 metres below the proposed bottom of the quarry…”
    • i.e. 11 boreholes per hectare vs cost of drilling/tender
    • NWD4/TNW barrel = ±60mm diameter core (0.0113m²)
      • 0.124m² vs 10 000m²
  • SAPEM is not a specification, but a guideline
What to do?

• Comprehensive laboratory test programs for intended application (e.g. G1)
• Be mindful of sample size vs volume of aggregate to be procured. Do multiple sets of tests
• Duplicate testing where possible/relevant
Specific tests focussing on basic crystalline material durability

• Current tests in isolation are not sufficient
• Best tests that indicate durability problems include:
  • Modified ethylene glycol durability index
  • Durability mill index (for G1?!)  
  • 10% FACT / Aggregate crushing value (dry, wet and ethylene glycol soaked)
  • Aggregate impact value
  • Petrographic analyses (i.e. XRD with thin section review)
  • Water absorption (especially fine fraction)
• Do not test in isolation!
• Consult an engineering geologist; start a rocky relationship!
• Do not assume that basic crystalline material durability is always the problem

• Investigate thoroughly and test comprehensively. Cost of additional drilling and laboratory tests is negligible compared with the costs of rebuilding a road

• Avoid marginal materials!
References


- Clauss, K.A. 1967. The pH of fresh and weathered dolerite as an indicator of decomposition and of stabilisation requirements. 4th Regional Conference for Africa on Soil Mechanics and Foundation Engineering, Cape Town, South Africa.


- Leyland, R.L., 2014. Factors affecting the durability of basic igneous rocks as high quality base course aggregates, an investigation of the Karoo Dolerite Suite of South Africa. PhD Thesis, University of Arizona, United States


Thank you!