banahCEM
GEOPOLYMER BINDER SYSTEM

Andrew McIntosh

Geopolymer Camp 2014
7 – 9 July 2014
St. Quentin
• Introduction to banah

• The banahCEM system

• Using banahCEM

• Design of banahCEM-based concretes

• The next steps...
Introduction

banah UK Ltd – The Company

- Formed November 2008
- Research and Development of Geopolymer Technology
- Construction of Production Plant for Geopolymer Cements
- Establishment of a Centre of Excellence for Novel Cements
- Reduction in the Future Environmental Impact of the Construction Industry
The banahCEM system

Powder Component - Precursor

- Calcined Clay-based Geopolymer
- Lower Kaolinite Contents
- Presence of Other Minerals that may Improve Performance
- National and International Availability
- Lower Environmental Impact and Cost
The banahCEM system

Powder Component - Processing

- Tailings from local quarrying and mining
- Material Ground and Dried
- Low Level Thermal Treatment
- Rapid Cooling
- Blending with Other By-Products
The banahCEM system

Liquid Component - Activator

- Alkali Silicate Solution
- Formulated to be User-Friendly rather than Caustic
- Needs to be Matched to the Precursor Material
- Optimised to Prevent Efflorescence
- Ultimate Aim is to have Solid Activator Component
Liquid Component - Production

• Two Options Available
  • Modified Commercially-available Silicate Solutions
  • Alternative Amorphous Silica-based Production of Alkali Silicate Solution

• Alternative Option Enables use of By-products Containing Amorphous Silica Source.

• Option Chosen Depends on End-Use

• Alternative Option has Lower Carbon Footprint
The banahCEM system

Scanning Electron Micrographs
Geopolymer vs Portland Cement

Geopolymer Binder

Portland Cement (32 Hours)
The banahCEM system

Scanning Electron Micrograph of Reacted Geopolymer
Using banahCEM

Batching and Placing

• Use Existing Concrete Batching Facilities

• Geopolymer Concrete More Viscous with Self-Levelling Properties

• Excellent Bond with Mild Steel and Low Shrinkage Values after Curing

• Strength Gain More Rapid Than Standard Cements

• Compressive Strengths of 130 N/mm² Achievable
Introduction

• Mix Design of Geopolymer concretes for commercial applications

• Selection of a suitable concrete mix for durability testing

• Comparison of banahCEM concrete with OPC

• BRE – Design of Normal Concrete Mixes

• Work carried out with Dr Jacek Kwasy of QUB
Design of banahCEM Concrete

banahCEM vs OPC

Compressive Strength (N/mm²)

banahCEM Solids Content (kg/m³)

- OPC 10mm 28 day
- OPC 10mm 7 day
- GPC 10mm 28 day
- GPC 10mm 7 day
Design of banahCEM Concrete

The diagram illustrates the relationship between paste volume (in liters per cubic meter) and compressive strength (in megapascals) as a function of water-to-slag (w/s) ratio. The data points show that:

- At a w/s ratio of 0.66, the paste volume is approximately 302.9 liters per cubic meter, leading to a compressive strength of 400 kg/m³.
- At a w/s ratio of 0.51, the paste volume is about 300.0 liters per cubic meter, resulting in a compressive strength of 450 kg/m³.
- At a w/s ratio of 0.45, the paste volume is around 314.2 liters per cubic meter, yielding a compressive strength of 500 kg/m³.
- At a w/s ratio of 0.43, the paste volume is close to 333.9 liters per cubic meter, with a compressive strength of 550 kg/m³.
- At a w/s ratio of 0.38, the paste volume is approximately 347.0 liters per cubic meter, leading to a compressive strength of 600 kg/m³.
- At a w/s ratio of 0.36, the paste volume is around 363.7 liters per cubic meter, resulting in a compressive strength of 650 kg/m³.

The chart indicates that as the paste volume increases, the compressive strength also increases, conforming to the expected behavior of concrete.
Design of banahCEM Concrete

Variation of Paste Volume at Fixed w/s Ratio

Compressive strength [MPa]

Paste volume [L/m^3]

1-day  3-day  7-day  28-day

w/s = 0.30
Design of banahCEM Concrete

Variation of Paste Volume and w/s Ratio

Paste volume = 280 L/m³

Paste volume = 300 L/m³
Design of banahCEM Concrete

Water Content Fixed at 137 L/m³

Water content = 137 L/m³
Relationship of Slump, Paste Volume and w/s Ratio

- Slump class S2

Design of banahCEM Concrete
BRE Design of Normal Concrete Mixes

‘... the strength of concrete is better related to the free-water/cement ratio...’

- Initial work has confirmed similar trends based on variation of w/s ratio
- Development of a set of charts to enable design of geopolymer mixes
- Work is being carried out on natural uncrushed aggregates

Figure 4 – from BRE Design of Normal Concrete Mixes
• Commencement of banahCEM Production

• Development of Standards for Geopolymer Cements

• Development of a 1-Part System

• Increased Use of Waste Alkali Streams for Some Applications
Website:
www.banahUK.co.uk

E mail:
andrew@banahUK.co.uk