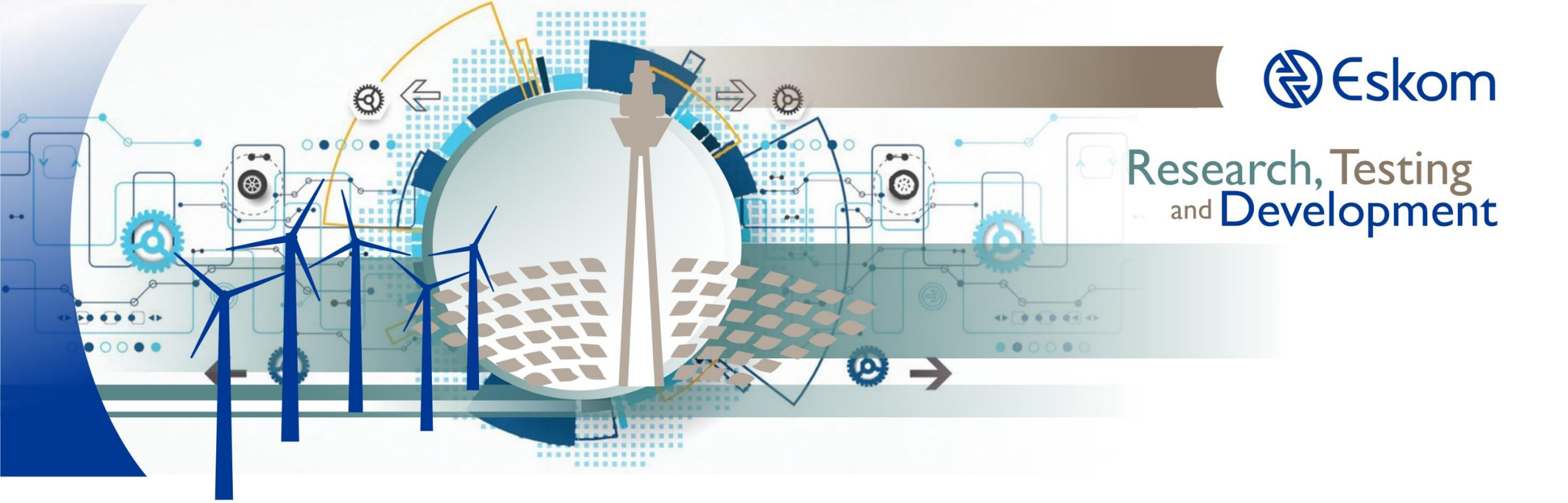


Eskom

Research, Testing and Development

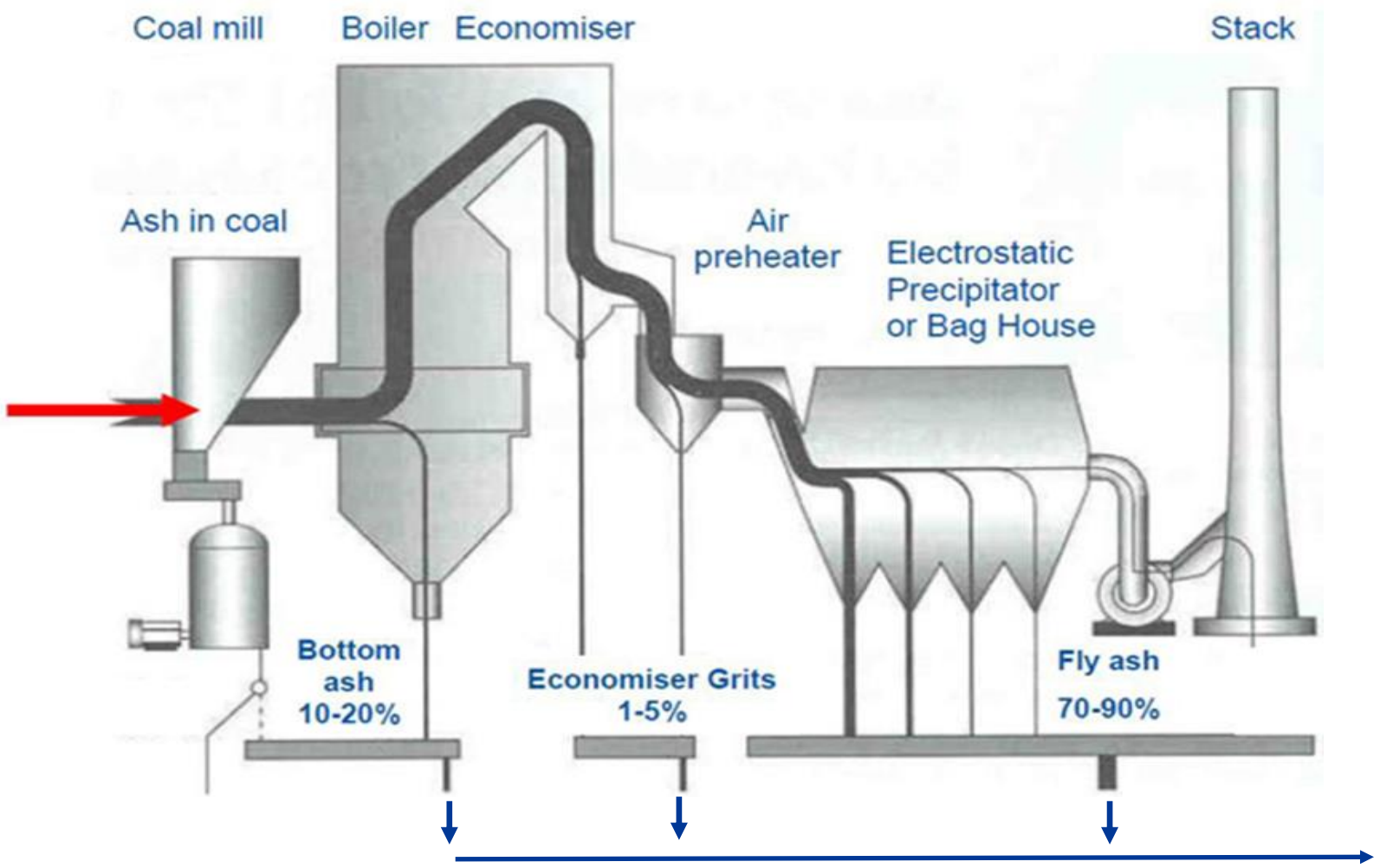
Ash Beneficiation Research

Date: 29 May 2025

Venue: Franklin Auditorium Megawatt Park

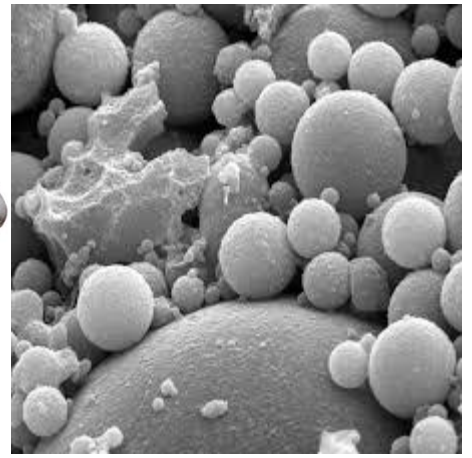
Presenter: Dr Kelley Reynolds-Clausen

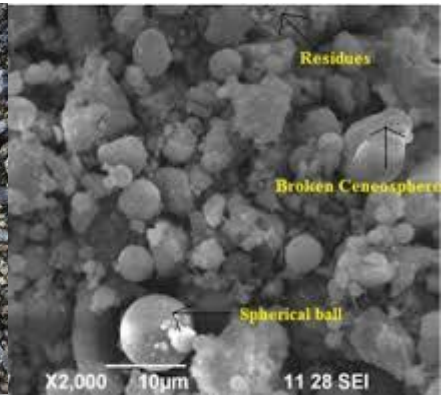
Coal ash generation



INTRODUCTION

- Dumped ash
  - Combination of 80:20 Fly ash : Bottom ash
  - Weathered
  - Reactive
  - Vast volumes – 3.2 billion tons.
  - Lower pH – 8.5
- Eskom ash unique physical and mineralogical properties from
  - Poor quality sub-bituminous parent coal
  - Combustion conditions
    - Size and pressure of the boilers
    - Temperature
    - Air : fuel
    - Milling
    - Rate of combustion
  - Emission control techniques
  - Climate
  - Ash
    - Highly alkaline, Low sulphur, Low carbon, Pozzolanic
- Beneficiation relies on one or more of the properties
  - Spherical shape, pH, Pozzolanicity, Variety of particle sizes.



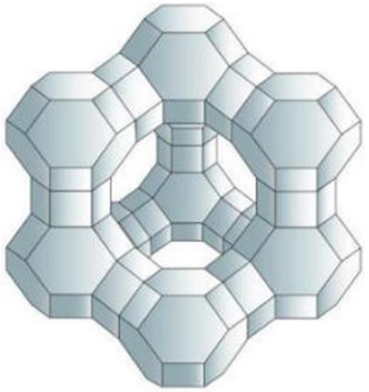


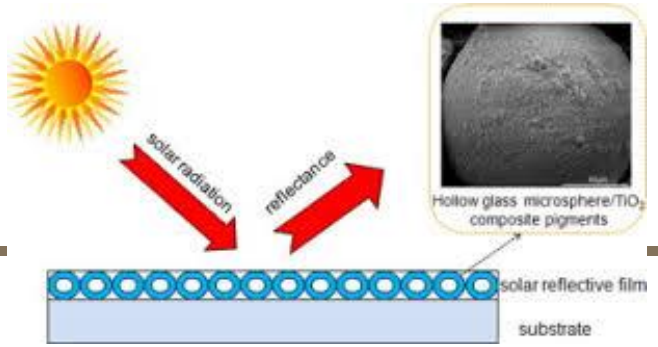
So, what can we do?

Well to start….

- Ash in Rubber extension - published
- Ash Mine Backfilling - published
  - Standards and Guidelines
  - Trials for environmental monitoring
- Zeolite production from Ash
- Ash in paint extension
- Ash to treat eutrophication in water

- Ash information books





Road Construction – Unstabilised fly ash

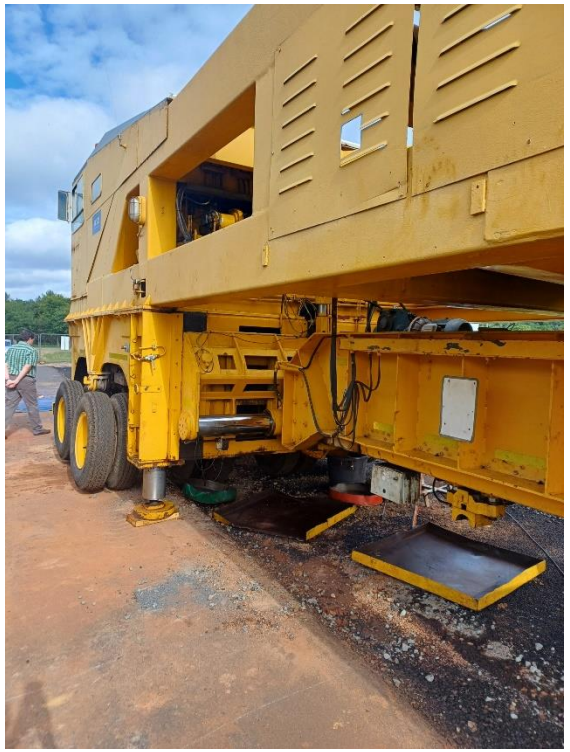
Fly ash utilisation in road construction

Basic laboratory studies
- Fly ash characterisation

Detailed laboratory studies
- Variability testing
- Strength behaviour
- Chemical and environmental

Trial sections
- Monitor response due to HVS trafficking
- Long-term performance assessment

Pavement Design
- Technical Guideline for the use of Fly Ash in Road Construction



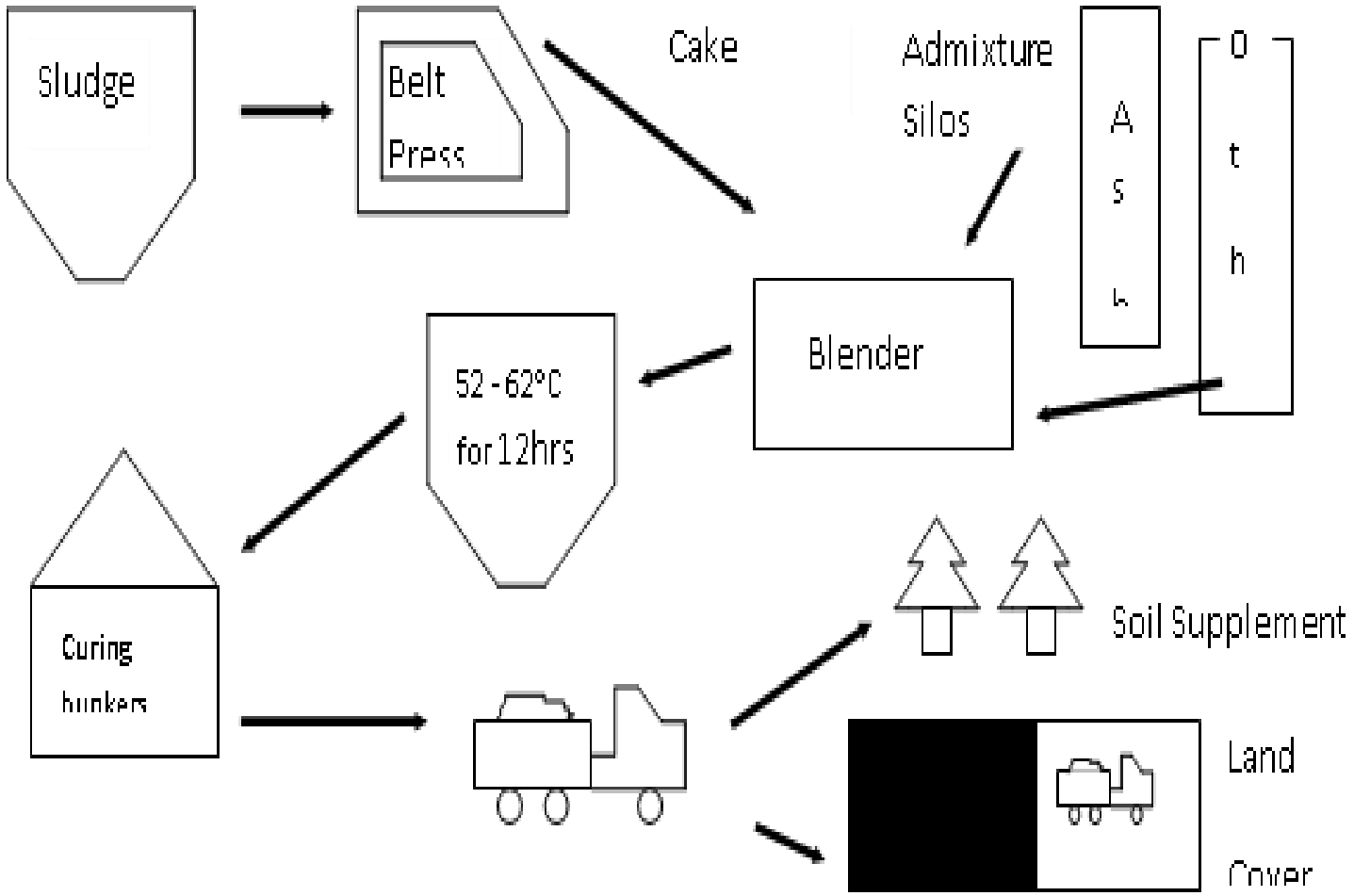
- Eskom Final report – Explanation of the laboratory and pilot scale work completed.
- Guideline on the use of unstabilised fly ash in road construction.

Soil Amelioration – Agricultural

Soil Amelioration - Mine impacted soils

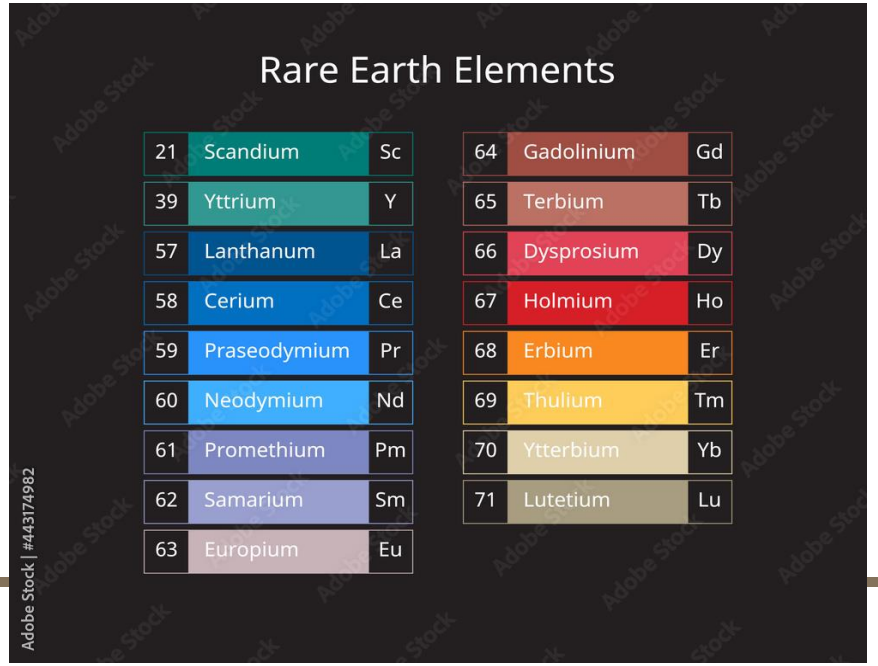
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

SLASH – Sewage, Lime ASH

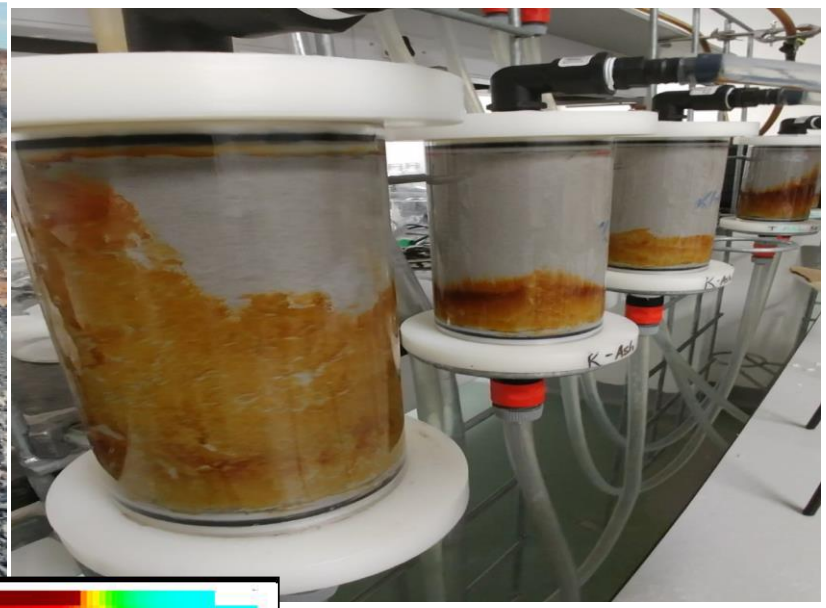


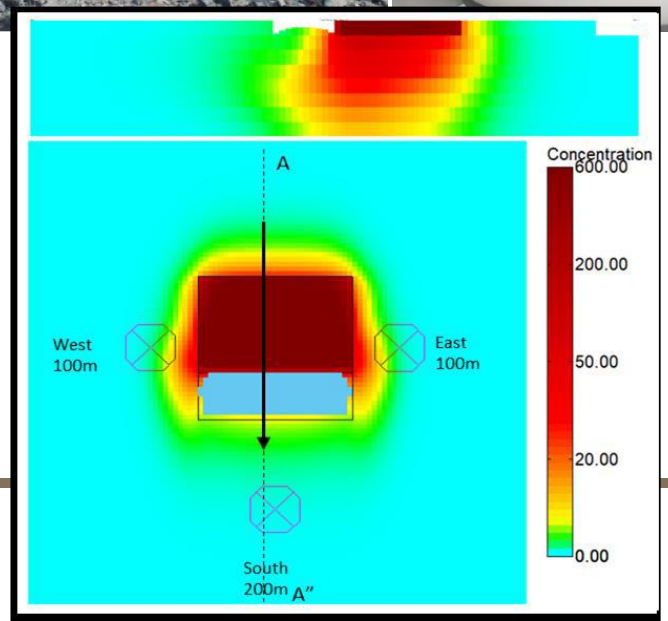
REE Extraction

- Rare Earth Elements mostly from China – have limited availability.
- Many research projects on extraction techniques, historically not cost effective.
- Need to understand what is available in Eskom ashes.
- Evaluated all dumped ashes in Eskom fleet.



Mine Backfilling



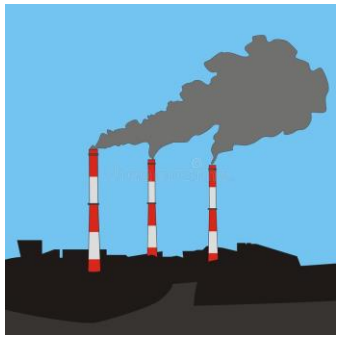


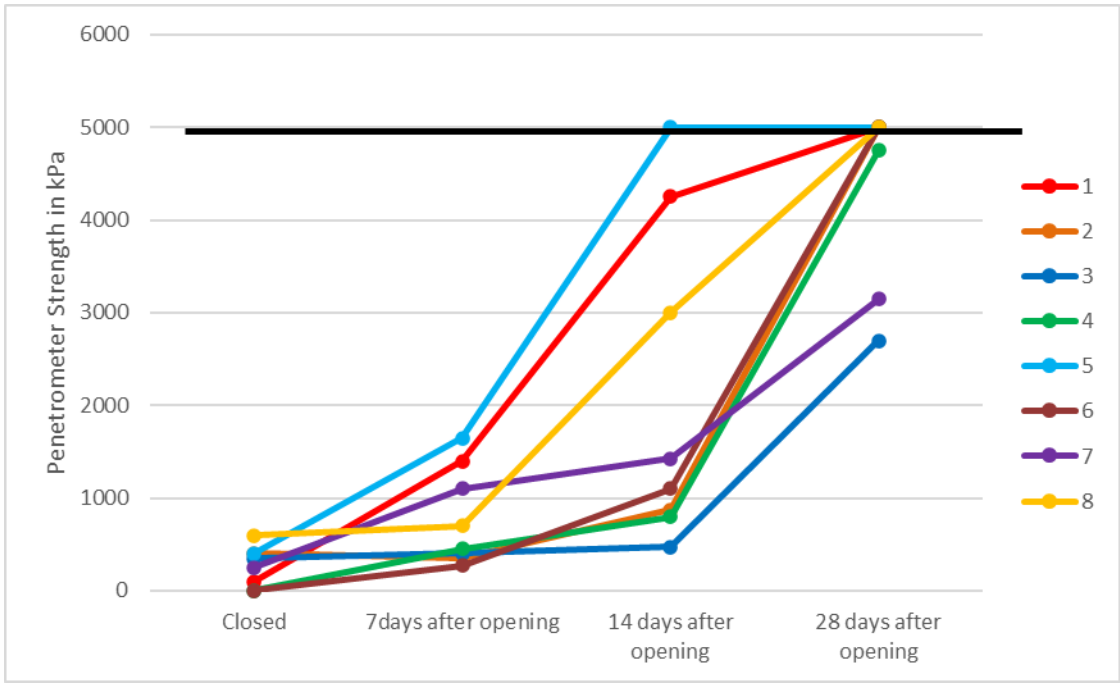
Mine Backfilling

CO_2 Reuse

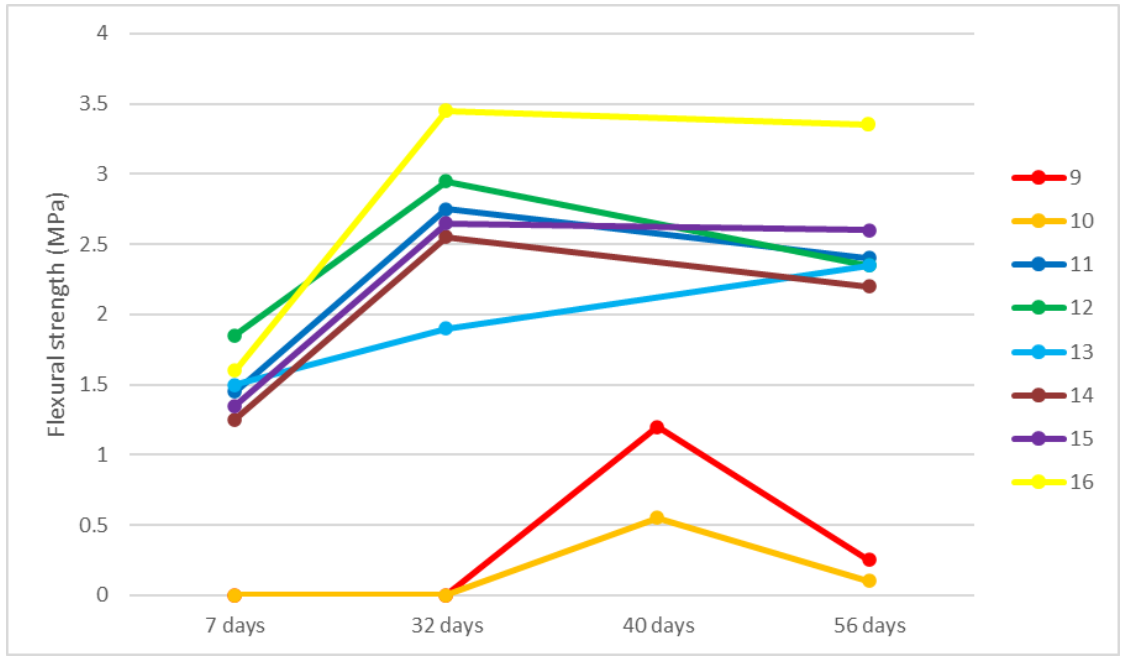
- Use of CO_2 and flue gas for enhanced curing and strength development in zero cement concrete.
- Carbon aids setting.
- Crystal formation enhanced.

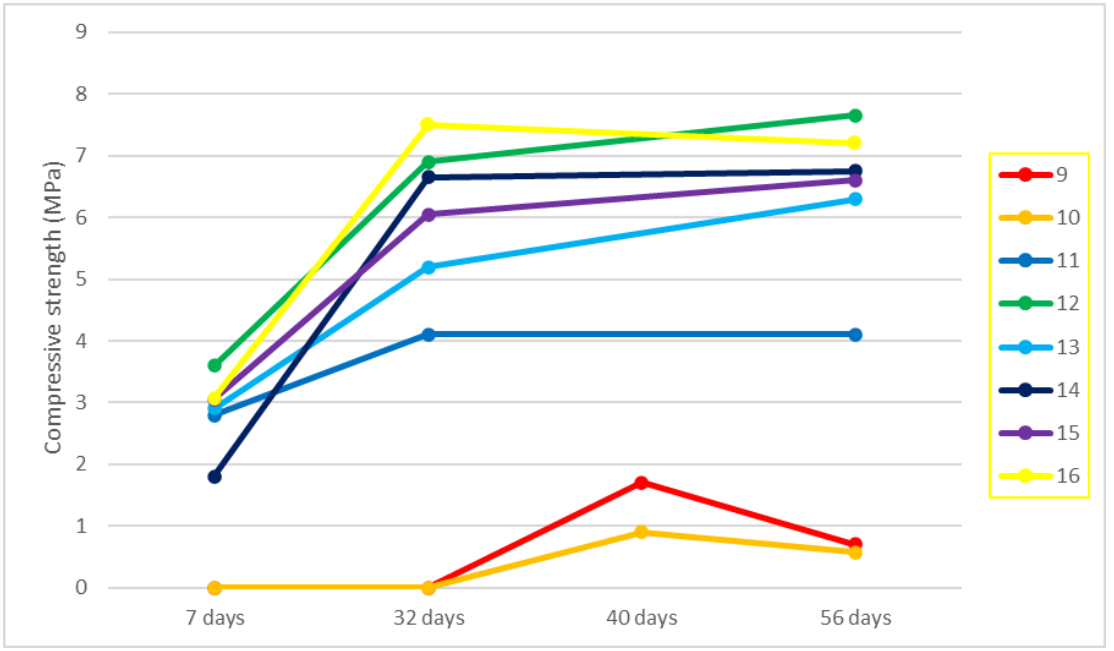
- Literature review complete.





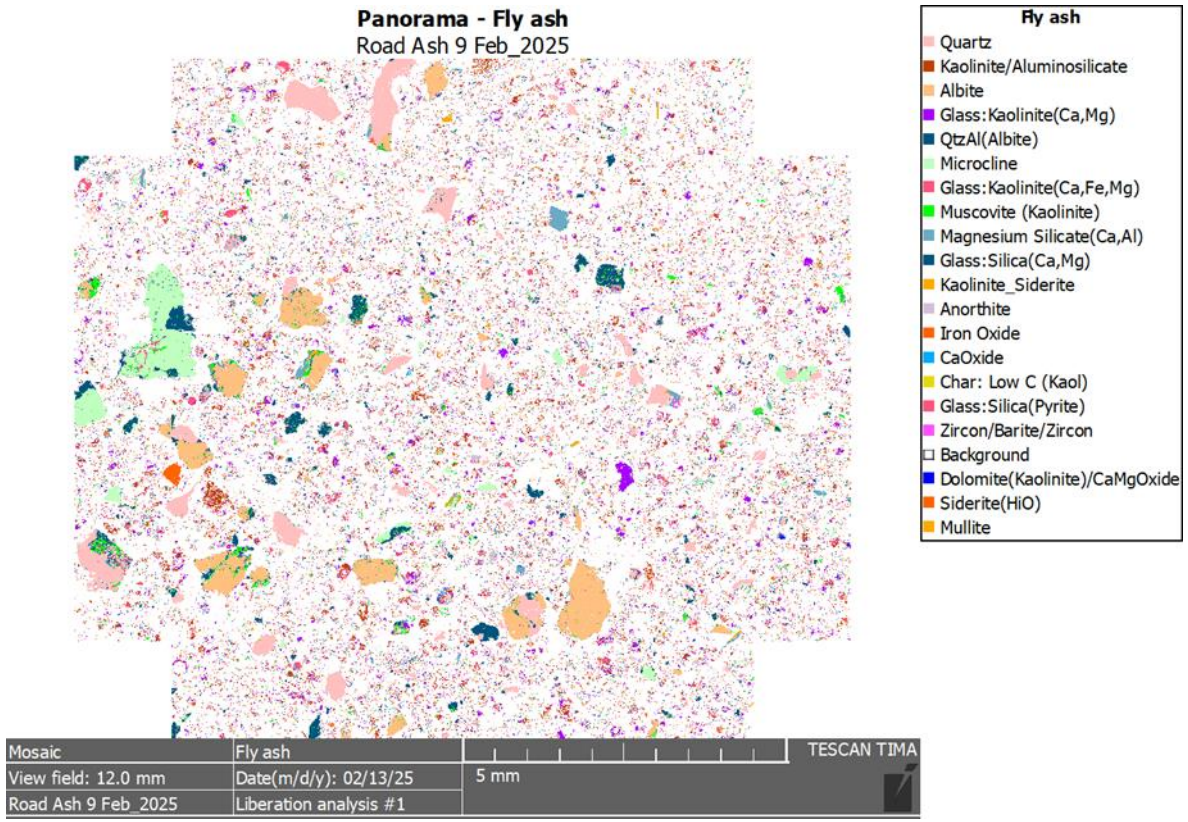
CO_2 Reuse

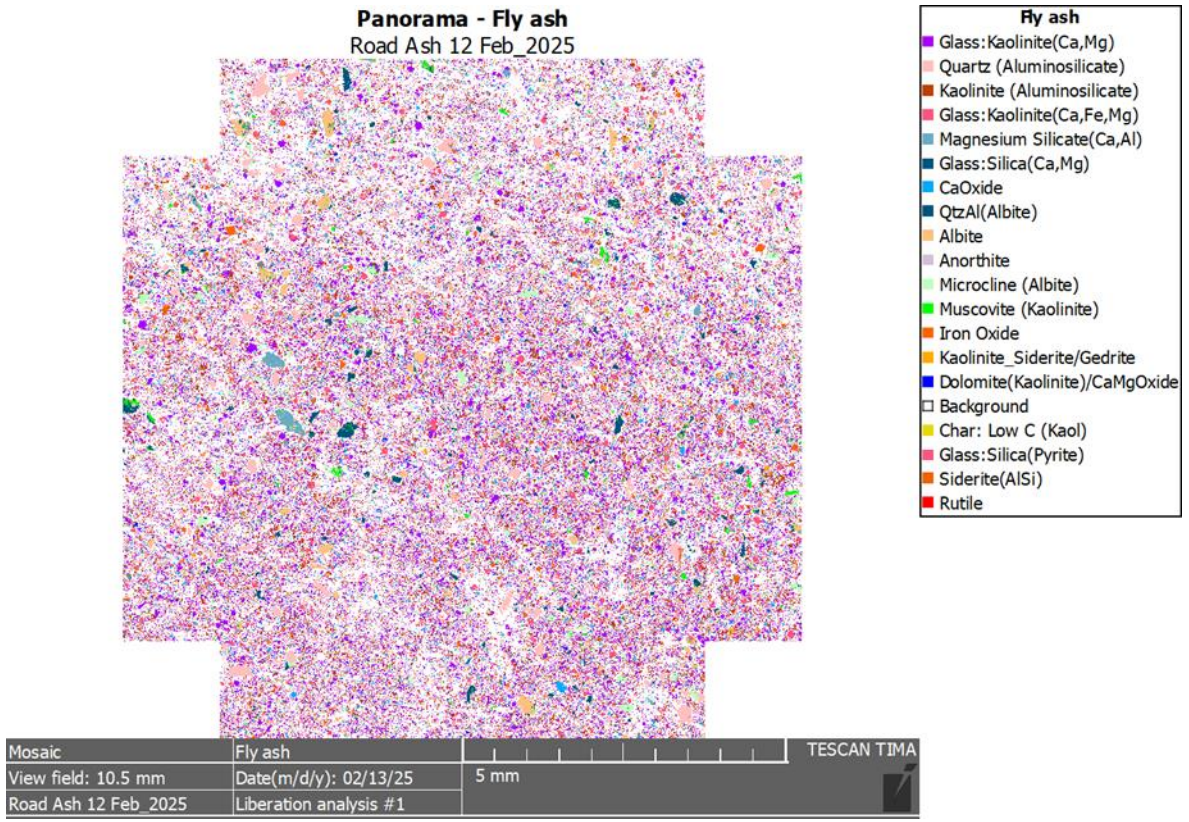




- Zero Cement.
- Sand aggregate.
- No Slag
- Up to 12.73g of CO_2 added per litre of water used for mixing.

CO_2 Reuse

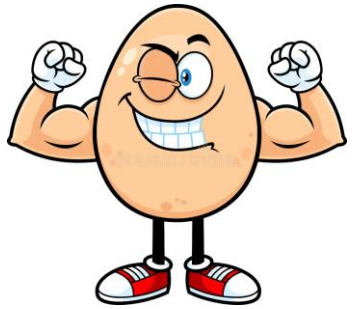

Panorama - Fly ash
Road Ash 9 Feb_2025
Fly ash
Quartz
Kaolinite/Aluminosilicate
Albite
Glass:Kaolinite(Ca,Mg)
QtzAl(Albite)
Microcline
Glass:Kaolinite(Ca,Fe,Mg)
Muscovite (Kaolinite)
Magnesium Silicate(Ca,Al)
Glass:Silica(Ca,Mg)
Kaolinite_Siderite
Anorthite
Iron Oxide
CaOxide
Char: Low C (Kaol)
Glass:Silica(Pyrite)
Zircon/Barite/Zircon
Background
Dolomite(Kaolinite)/CaMgOxide
Siderite(HiO)
Mullite
Mosaic
Fly ash
TESCAN TIMA
View field: 12.0 mm
Date(m/d/y): 02/13/25
5 mm
Road Ash 9 Feb_2025
Liberation analysis #1

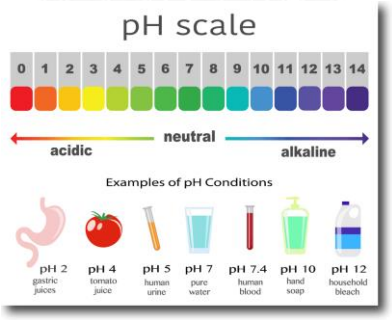

Panorama - Fly ash
Road Ash 12 Feb_2025
Fly ash
Glass:Kaolinite(Ca,Mg)
Quartz (Aluminosilicate)
Kaolinite (Aluminosilicate)
Glass:Kaolinite(Ca,Fe,Mg)
Magnesium Silicate(Ca,Al)
Glass:Silica(Ca,Mg)
CaOxide
QtzAl(Albite)
Albite
Anorthite
Microcline (Albite)
Muscovite (Kaolinite)
Iron Oxide
Kaolinite_Siderite/Gedrite
Dolomite(Kaolinite)/CaMgOxide
Background
Char: Low C (Kaol)
Glass:Silica(Pyrite)
Siderite(AlSi)
Rutile
Mosaic
Fly ash
TESCAN TIMA
View field: 10.5 mm
Date(m/d/y): 02/13/25
5 mm
Road Ash 12 Feb_2025
Liberation analysis #1

Why Coal ash geopolymer concrete materials?

- Fly ash and slag inexpensive raw material (wastes)
- High Silica (40 – 60%) and aluminium contents (20 - 30%)
- Low calcium, sulphur, carbon (unburnt coal) and iron concentrations

- Environmentally friendly – No CO_2 emissions
- Considered user friendly – new activators
  - Conventional activators – hazardous, toxic and corrosive
- Can cure at a wide range of temperatures.
- Various strengths and flexibilities.
- Better heat resistance - no hydrates in structure.
- Resistant to corrosion from saline, acidic or alkaline environments - attributed to the lack of calcium in their structure.





Geopolymer Poles (wood replacement)

- 9 and 11m wooden pole replacement.
- Fire, moisture (rain and rot) and pest (termites, borer beetles) resistance.
- Must meet specifications for wood poles and SANS 720 for concrete poles.

Geopolymer Poles - formulations

- 1m laboratory trial cast pole formulation
  - Dumped coal ash and slag
  - Day 1 - 18.6 MPa, day 3 - 33.4 MPa, day 7 - 42.8 MPa and day 28 - 61.8 MPa – compressive strength.
  - 12.6 MPa Flexural strength after 28 days
- Spun pipes
- No metal reinforcing – plastic fibre.
- Non-hazardous activators

Geopolymer Poles - Production

Coal ash-based Shotcrete

- Fly ash-based Shotcrete
  - Spray on – minimal bounce off
  - Sets within 2s – 1.5 mPa
  - 70mPa after 28 days and 150 mPa after 6 months – cannot be cut with diamond blade.
- Tx telecoms – buildings and containers to be sprayed to reduce vandalism and theft and to insulate the buildings.

Poor Quality Soil Improvement – foundations - Tx

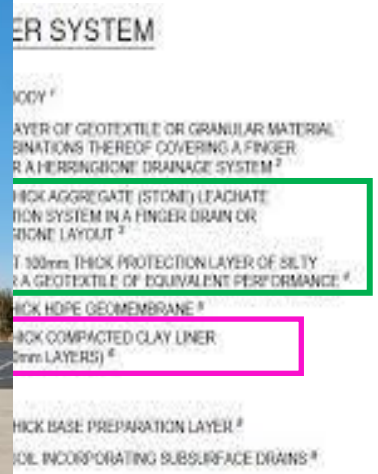
- Improvement of active clay, compressive or compacting soils
- Addition of coal ash, slag and activator to soil → improves soil grading.
- Strength – 0.75MPa
- Beneath substations for construction support.
  - 300m x 300m x 1.5 – 3m of earth work removal.

Can reduce the cost of substation base construction from approximately R63 M to approximately R22 M per 300x300m sub station.

Not considering savings on testing, machinery and manpower on the lesser volume.

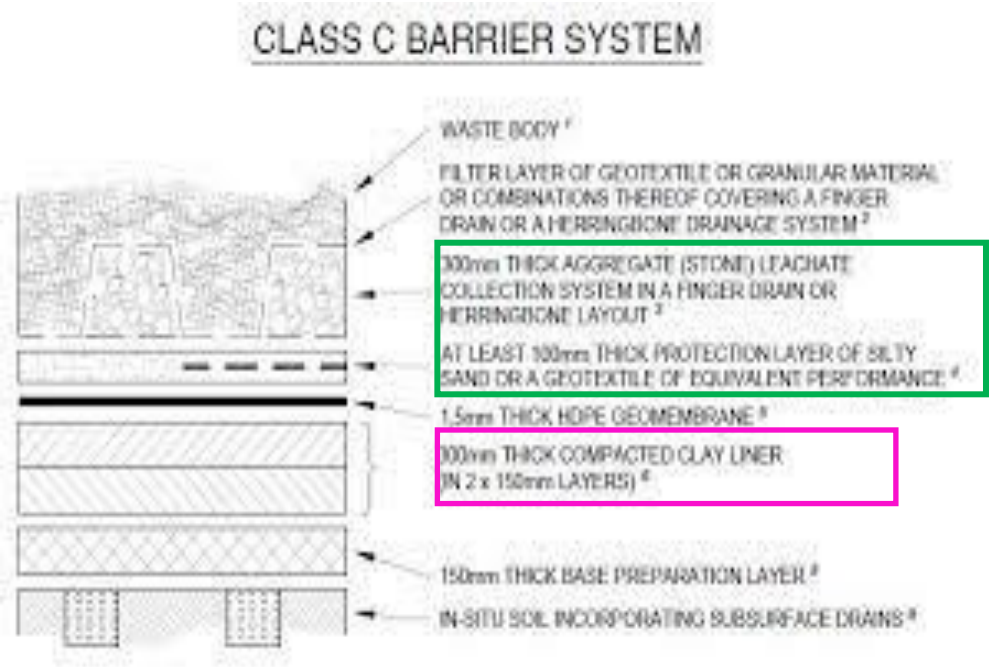
Waste Liners – What can we do?

- Cushion/
  - Use
    perm
    sand
  - Only
  - Non-
  - Tech
  - Triall
  - No fu
  - Gove
  - Savi
    thick
  - Savi



Waste Liners – What do we need to do?

- Stabilised clay layer – Below HDPE
  - Stabilised ash/soil as an impermeable layer.
    - Needs approval from government
    - Initial work conducted for Tx substation stabilisation.
    - **More research required** – cannot be used at present.
    - Possible saving of approx. R400 – R700/m^3
    - Concept agreed by Department of Fisheries, Forestry and the environment.
      - Prove impermeability
      - Prove flexibility
      - Prove durability



Conventional Road Construction

- Utilise virgin aggregate (rock) material to develop the support layers.
- Material is obtained from borrow pits in the area around the road construction.
- The materials, placed in reducing size are processed and stabilised with conventional cement.
- The top layer is bitumen as a wearing course.

Geopolymer Ash Road Construction (engineered layers)

Kusile PS - Geopolymer Ash Road – stabilised layers

- Pilot demonstration project – Kusile Power Station 2 x 500m x 8m wide roads.
- Utilise legacy coal ash and G5 material (50:50) in the base and sub-base; C4 and C3 engineered stabilised layers.
- Reduction of cost of materials
- Reduced use of mined virgin materials.

Benefits of the geopolymer ash road to Eskom

- Reduced cost of construction materials.
- Reduction of ash management costs and rehabilitation.
- Can use waste-water in the construction.
- Reduced use of Cement allows for the claiming of carbon credits.
- Utilise 840 tons of legacy ash per 150mm layer of C3/C4 per kilometer.
- 50:50 ratio of ash to G5 material only due to criticality of the road – will optimise the use of ash in further research.

Geopolymer Ash Road Construction (wearing course)

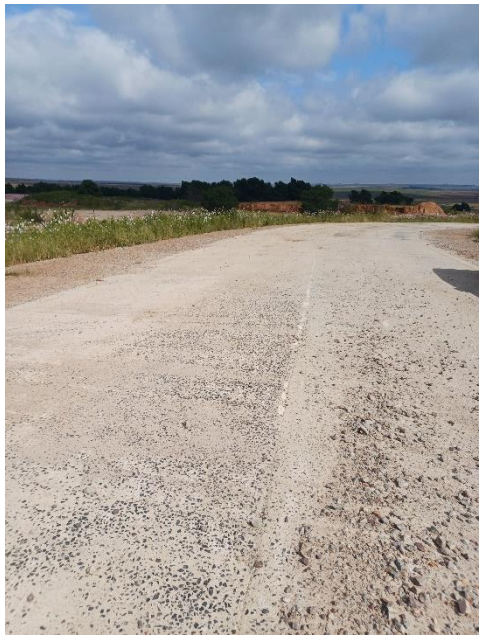
Kusile PS - Geopolymer Ash Road – Wearing Course

- Pilot demonstration project – Kusile Power Station 2 x 500m x 8m wide roads.
- Utilise legacy coal ash and metal processing waste (slag) to form a 30MPa ash concrete for the top wearing course.
- Reduction of cost of materials.
- No cement use.

Benefits of the geopolymer ash road to Eskom

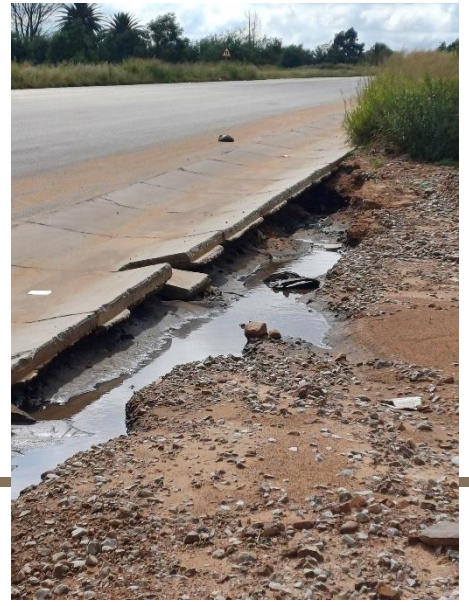
- Reduced cost of construction materials.
- Reduction of ash management costs and rehabilitation.
- Can use waste-water in the ash concrete batching.
- Reduced use of Portland cement allows for the claiming of carbon credits.
- Utilise 384 tons of legacy ash per 150mm layer per kilometer in the wearing course.

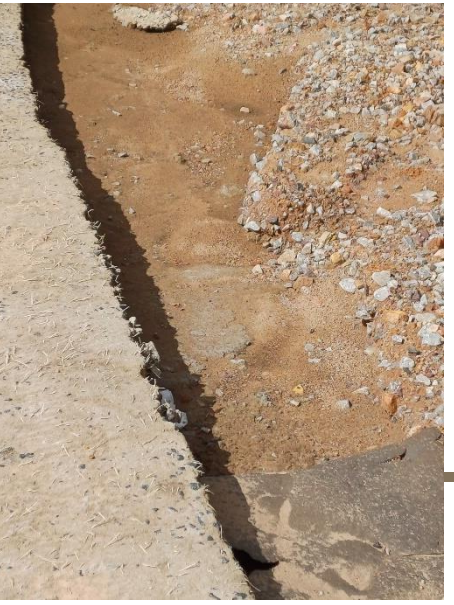
Inspections









Potential impact

Claiming of carbon credits

- Cement: 1 ton of CO2 per ton. Conventional road - 320 kg of cement is used per 1m^3.
- Ash road cement limited to 25-46kg/m^3) = 792.5 tons saving of CO2/km.
- Carbon rebate of R230/ton = R182 275/km of ash road produced.

Reduced ash disposal facility (ADF) costs

- Ash management R30/ton.
- Ash road used 2 904 tons ash/kilometer = **saving of R87 120/km by avoiding ash management**.
- Reduced ash handling, management and rehabilitation and **reduces liner development.**

Reduced materials costs

- Conventional road needs 6 270 tons of imported G5 material ~ R450 per ton = R2.8 million.
- Ash road needs 3 135 tons = R1.4 million, thus a **R1.4 million saving**.

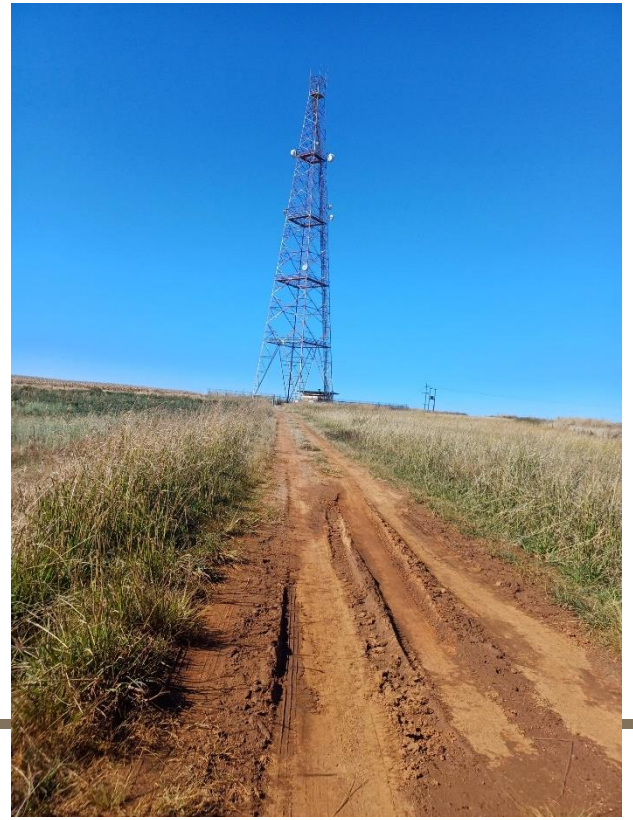
No Waste material

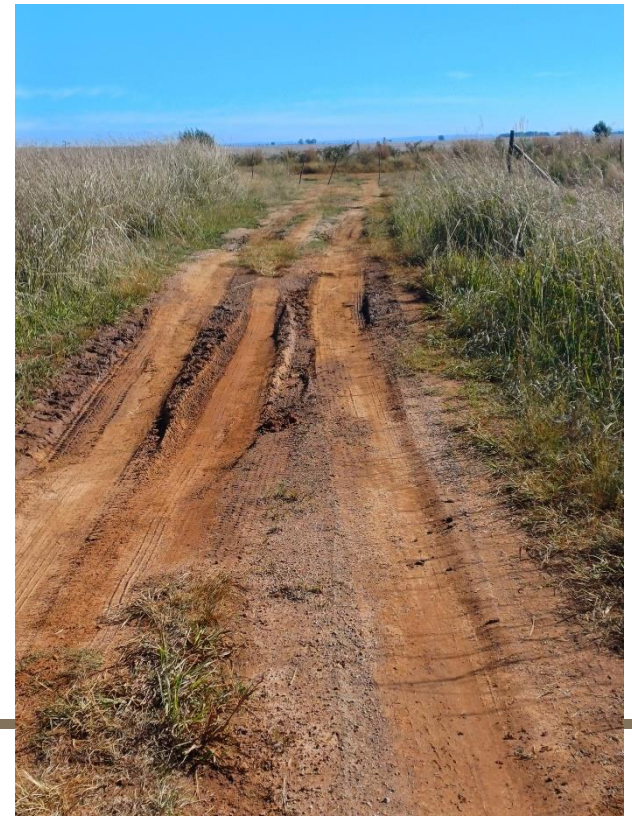
- No waste road material as is incorporated as aggregate,
- No waste dumping costs.

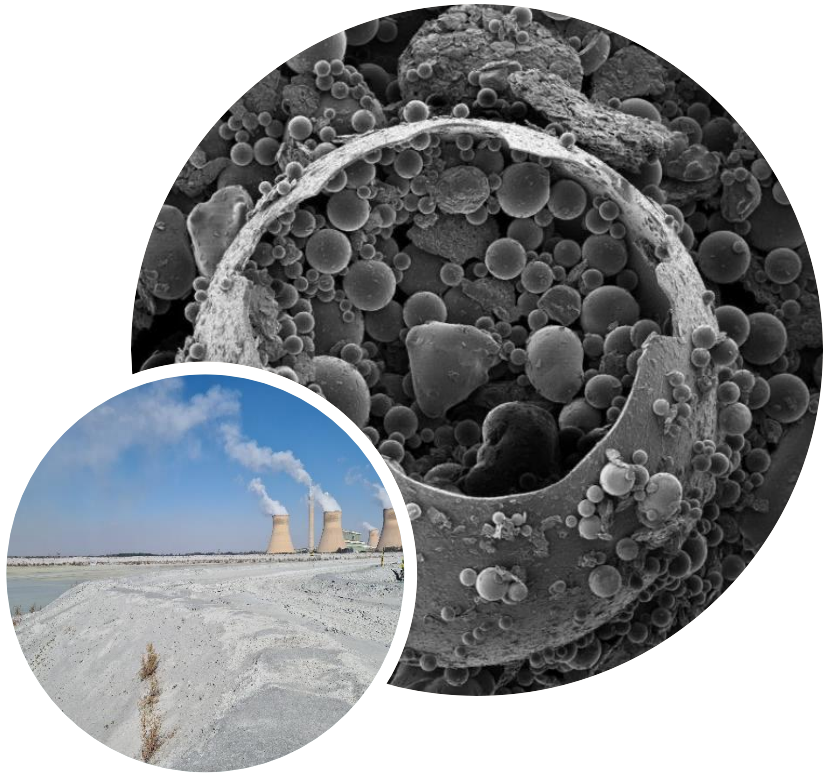
No leaching

- Stabilised **ash does not leach or react with water**. It is a more stable material, **less likely to pothole formation.**

New work







THANK-YOU

Questions?

Kelley Reynolds-Clausen
Reynolka@eskom.co.za
082 880 5642