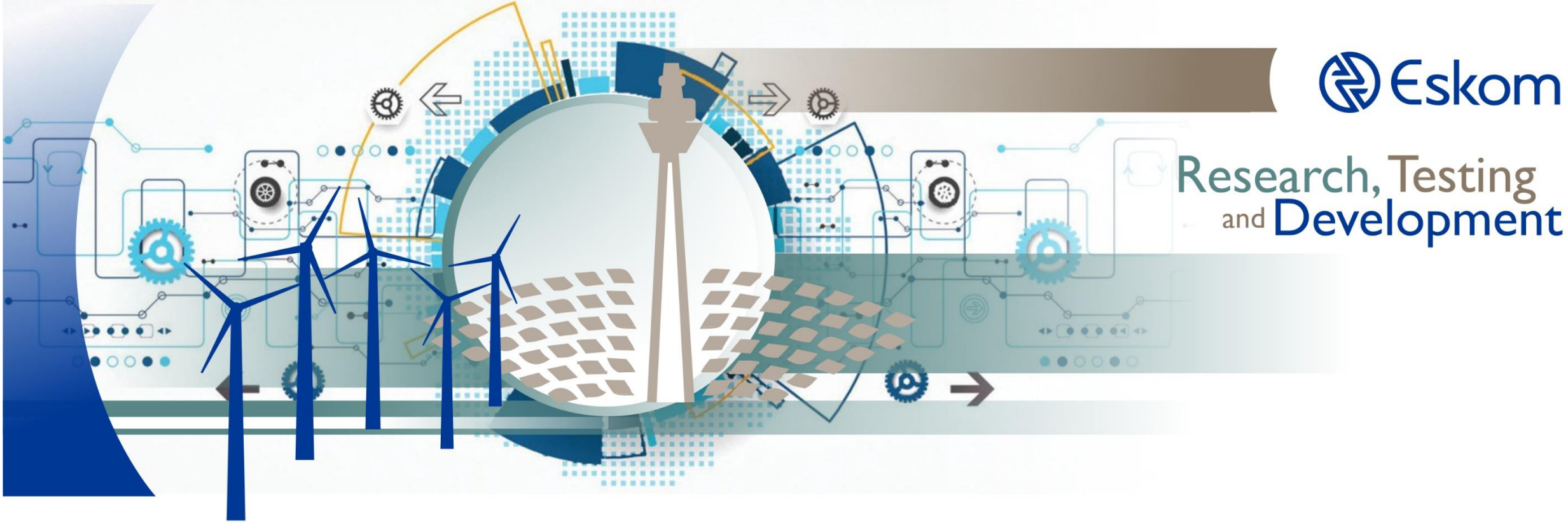


Eskom

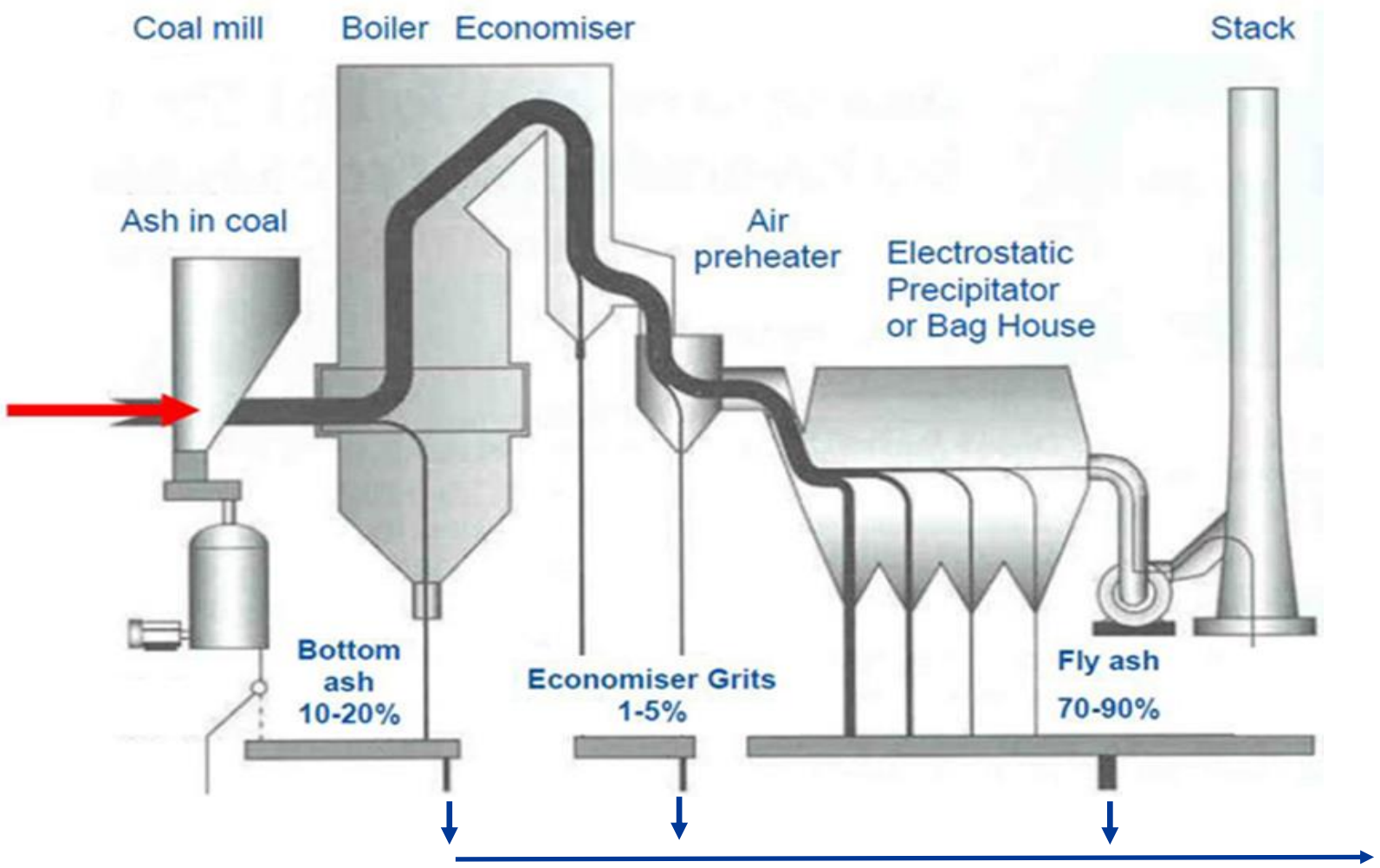
Research, Testing and Development

The use of Legacy Coal Ash for Road Construction – the First in the World

by Kelley Reynolds-Clausen

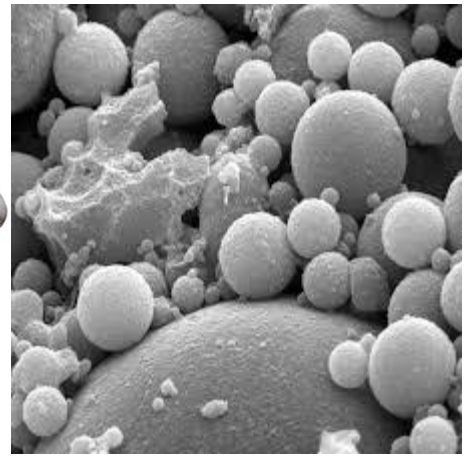
Date: 6 November 2024

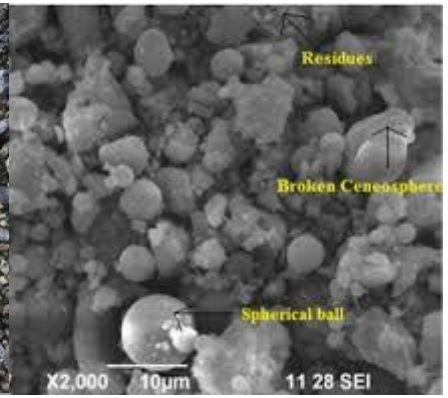
Coal ash generation



INTRODUCTION

- Grey powder formed by inorganic matter after combustion of coal.
- Fly ash
  - Small, fine particles (0.01-100µm diameter)
  - 85-90%
  - Spherical glass aluminosilicate
  - Captured by ESP or bag filters
- Coarse / Bottom ash
    - Heavier particles
    - 10-15%
    - Base of the boiler
    - Collected by submerged scraper conveyor
- Dumped ash
    - Combination of 80:20 Fly ash : Bottom ash
    - Weathered
    - Reactive
    - Vast volumes

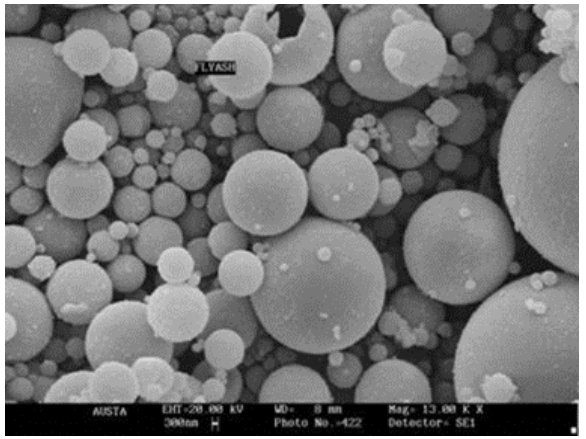




INTRODUCTION

- Obtains physical and mineralogical properties from
  - Sub-bituminous parent coal
  - Combustion conditions
    - Temperature
    - Air : fuel
    - Milling
    - Rate of combustion
  - Emission control techniques
  - Climate
- Classified as Class C (W) (calcareous) or **Class F (V) (silaceous)** ashes
- Eskom ash is unique worldwide
  - Size and pressure of the boilers (combustion techniques)
  - Poor quality coal used
  - 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

Properties	Fly Ash Classes	
Silicon dioxide, aluminium oxide, iron oxide	Class F	Class C
($SiO_2 + Al_2O_3 + Fe_2O_3$), min, wt.%	70,0	50,0
Sulphur trioxide (SO_3), max, wt.%	5,0	5,0
Moisture content, max, wt.%	3,0	3,0
Loss on ignition, max, wt.%	6,0	6,0



Road Construction

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

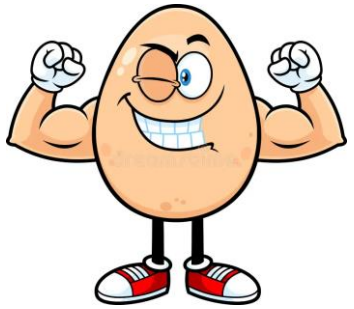
Pavement Design

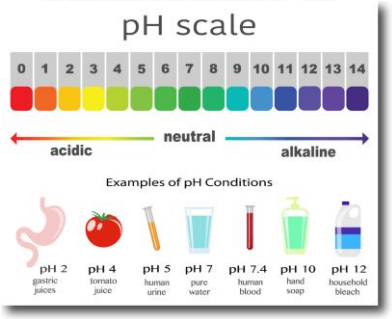
Technical Guideline for the use of Fly Ash in Road Construction

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.





Conventional Road Construction

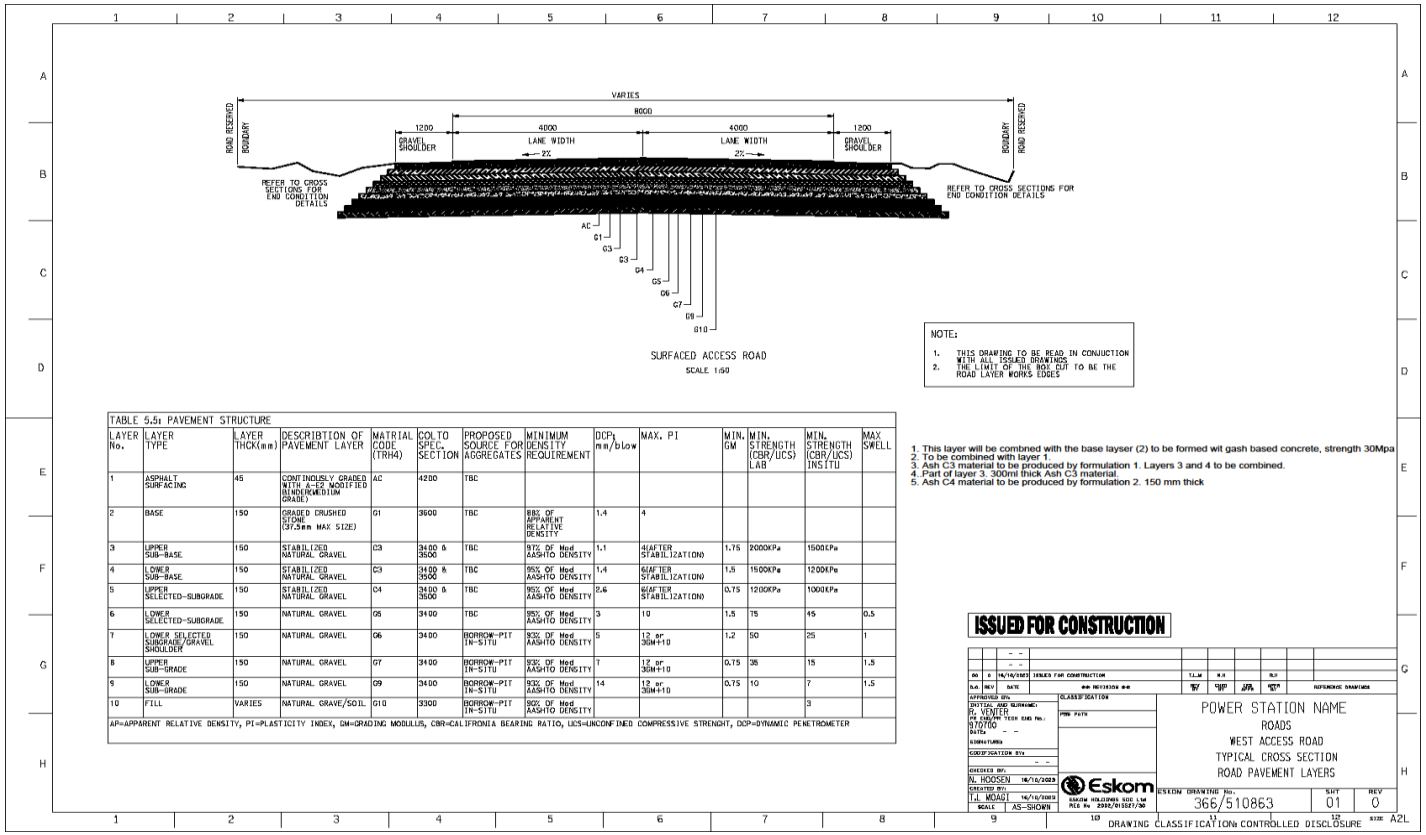
- Utilise virgin aggregate (rock) material to develop the support layers.
- Material is obtained from borrow pits in the area around the road construction.
- The materials, placed in reducing size are processed and stabilised with conventional cement.
- The top layer is bitumen as a wearing course.

Geopolymer Ash Road

- Pilot demonstration project – Kusile Power Station 2 x 500m x 8m wide roads.
- Utilise legacy coal ash in the base and sub-base; C4 and C3 engineered stabilised layers.
- Reduction of cost of materials
- No use of mined virgin materials.

- Legacy Ash
- Slag
- Activators
- Aggregate
- Water – from site
- 34MPa after 7 days

- Reinforcing – plastic fibre.



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 R190/ton = R150 575/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 rebar reinforcing

- Metal rebar in wearing course would cost R500 000/km conventionally.
- Plastic fibre → improved flexibility and better energy adsorption, costs R50 000/km, a 90% reduction.

No leaching

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

Geopolymer Ash Road – Initial pavement works

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

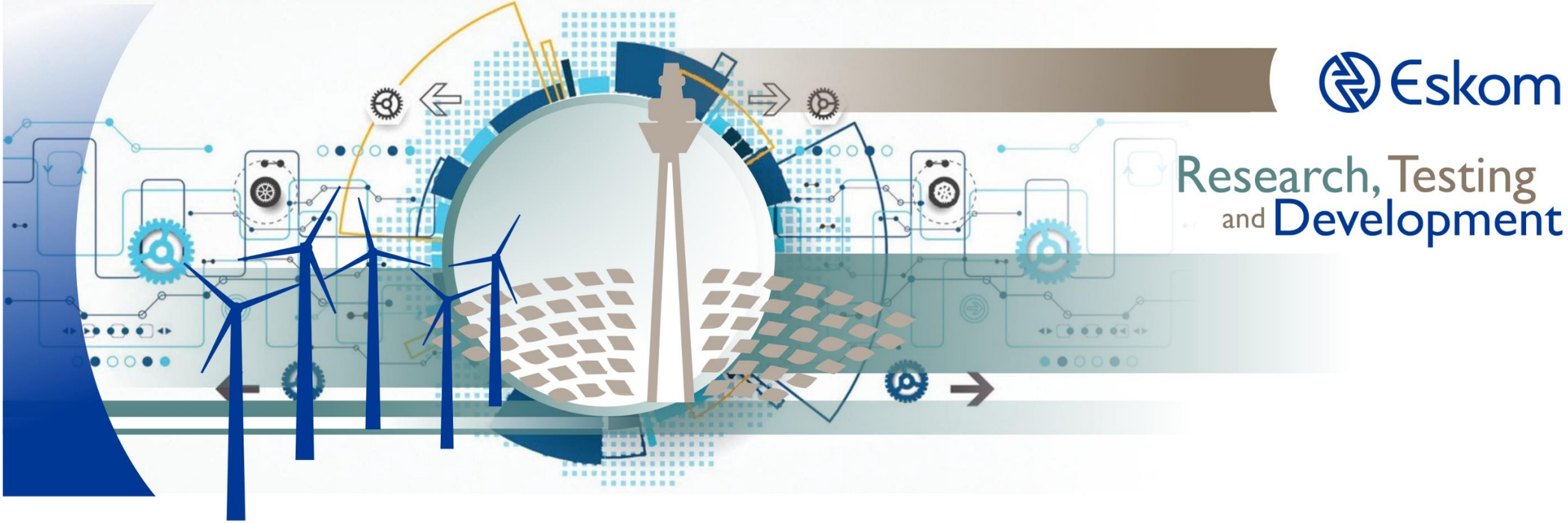
- Reduced cost of construction materials.
- Reduction of ash management costs and rehabilitation.
- Can use waste-water in the ash concrete batching.
- Reduced use of Portland cement allows for the claiming of carbon credits.
- Utilise 384 tons of legacy ash per 150mm layer per kilometer in the wearing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

Road Construction – Final product

Road Official Opening – 26 September 2024

Next Steps

- Ash Based Rehabilitation of the Matla Kriel connecting road.
  - Using Matla legacy ash
  - Dumped slag
  - Activators (South African – environmentally friendly)
  - Wastewater (pollution control dam)



Thank you for attending…

Please contact me with any questions (reynolka@eskom.co.za)