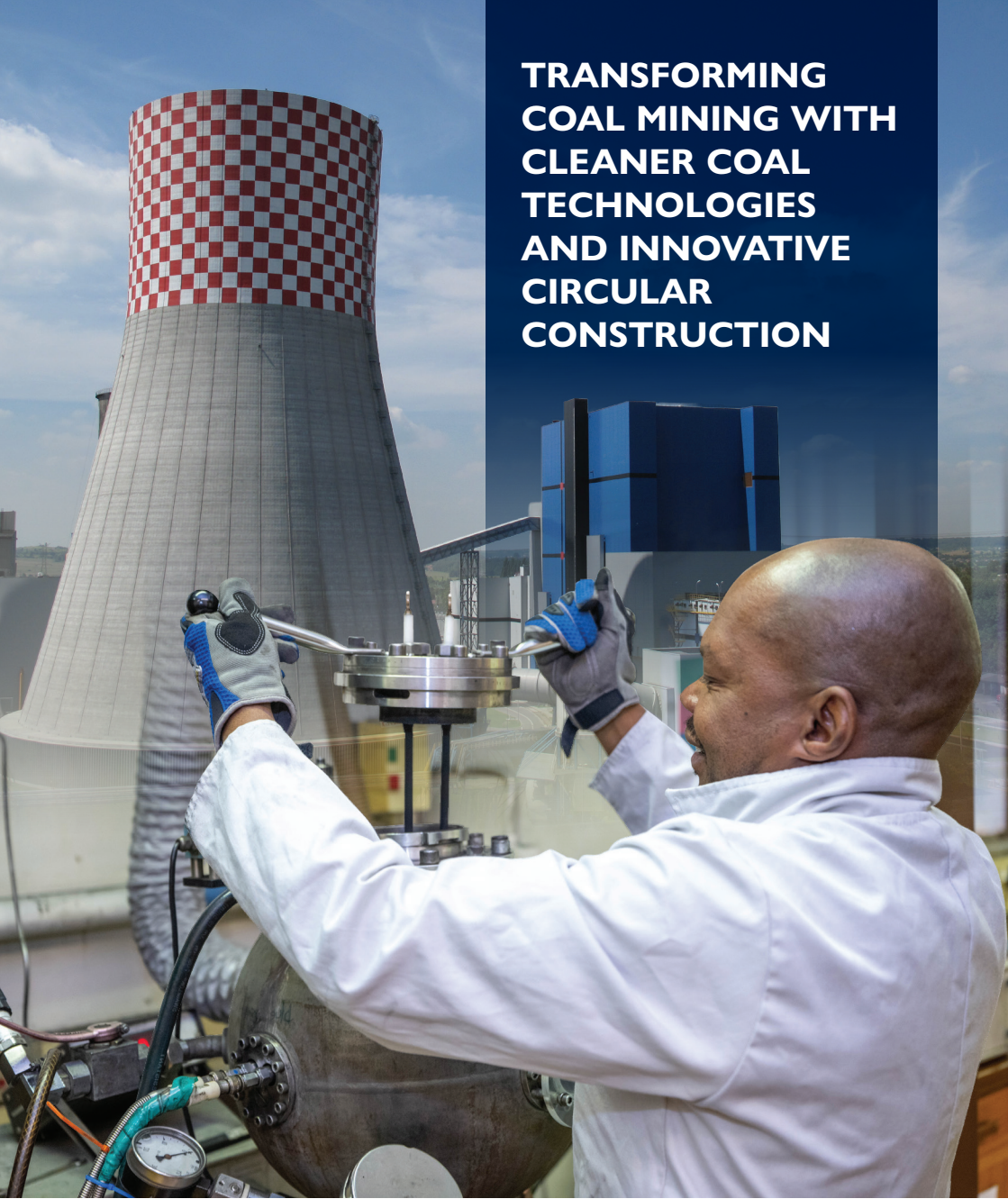


TRANSFORMING COAL MINING WITH CLEANER COAL TECHNOLOGIES AND INNOVATIVE CIRCULAR CONSTRUCTION



science, technology
& innovation

Department:
Science, Technology and Innovation
REPUBLIC OF SOUTH AFRICA



SCIENCE FOR SAFETY



Coal dust explosibility testing for improved assessment of underground explosion risks

The CSIR recognises the importance of advancing scalable methods and technologies aimed at transforming mining safety, and we have developed an enhanced method for evaluating and interpreting coal dust explosibility characteristics to reduce inherent safety risks.

Methane ignitions and coal dust explosions remain high-consequence hazards in underground coal mining, requiring appropriate risk control measures. The accurate assessment of coal dust explosibility plays a critical role in designing effective safety measures and reducing the risk of large-scale explosions.

This CSIR-developed method makes use of the internationally recognised 20-litre explosion vessel,

producing results that are aligned with global best practices. Hosted at our Kloppersbos Fire and Explosions testing facility, this unique capability accurately characterises the explosibility of the coal sample and enables the mine to translate the results to real underground atmospheric conditions, including temperature, humidity and methane levels, providing a more realistic assessment of explosion risk in underground coal mines.

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Fire and Explosion Testing and Training offerings

Our Kloppersbos Fire and Explosion Testing and Training facility, based north of Pretoria, is home to a range of unique test, research and development facilities. Recognised worldwide, this facility is equipped to conduct full-scale tests that recreate methane ignitions, underground fires and coal dust explosions in a controlled environment overseen by competent personnel.

Our safety training is designed to reinforce awareness among underground mine workers of the dangers associated with methane and coal dust mixtures and fires in the underground environment and how to mitigate these risks. Training tailored to hard rock mining, such as gold and platinum, is also available. Our competency-based training in mine emergency response employs modern technology to deliver an enhanced solution to meet the mining industry's training needs.

Miners receive training in best practices to prevent potential dangers and how to deal with hazardous conditions underground. The training includes large-scale demonstrations of a conveyor belt fire, methane ignition and a powerful coal dust explosion.



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Turning coal waste into high-performance road materials

Smart ash – a circular mix for modern mobility

At CSIR Smart Mobility, we help industry unlock value from coal ash and coal waste by converting these materials from environmental liabilities into engineered inputs for sustainable transport infrastructure. Our expertise spans research, testing, validation and implementation to support safer, lower-impact and more cost-effective road construction solutions.

Partner with us to scale circular mobility solutions

As demand for practical circular-economy solutions grows, the CSIR is opening new pathways for coal-derived by-products in the road construction sector. We work with partners across the coal, mining, transport and chemical value chains to develop, validate and commercialise applications that deliver measurable environmental and economic value.

We bring together multidisciplinary capabilities in materials science, pavement engineering and applied research to co-create solutions with industry. Whether the goal is reducing waste stockpiles, lowering embodied carbon, improving material performance or developing fit-for-purpose specifications, the CSIR provides the technical foundation to move from concept to deployment.

Proven expertise in circular materials for transport infrastructure

Our researchers investigate how waste streams can be repurposed into reliable road construction materials, reducing dependence on virgin resources and supporting more sustainable infrastructure delivery. This work aligns engineering performance with circular-economy objectives.

Our work includes the use of coal fly ash in unbound pavement layers, where we assess material behaviour, structural performance and long-term durability under realistic operating conditions.

CSIR's research is advancing the circular use of Eskom coal fly ash as a functional construction material that reduces waste and lowers reliance on virgin aggregates.

With Eskom generating about 34 million tonnes of ash annually and less than 10% currently reused, the opportunity for impact is significant. Our testing and accelerated assessments have shown that blends containing approximately 20% fly ash in unbound pavement layers can meet strength and durability requirements without added activators.

Trial road sections and heavy-vehicle simulations have demonstrated improved performance together with reduced carbon impact. This work has produced practical implementation guidelines and has already supported successful application on a power station access road, showing how research can be translated into deployable infrastructure solutions.

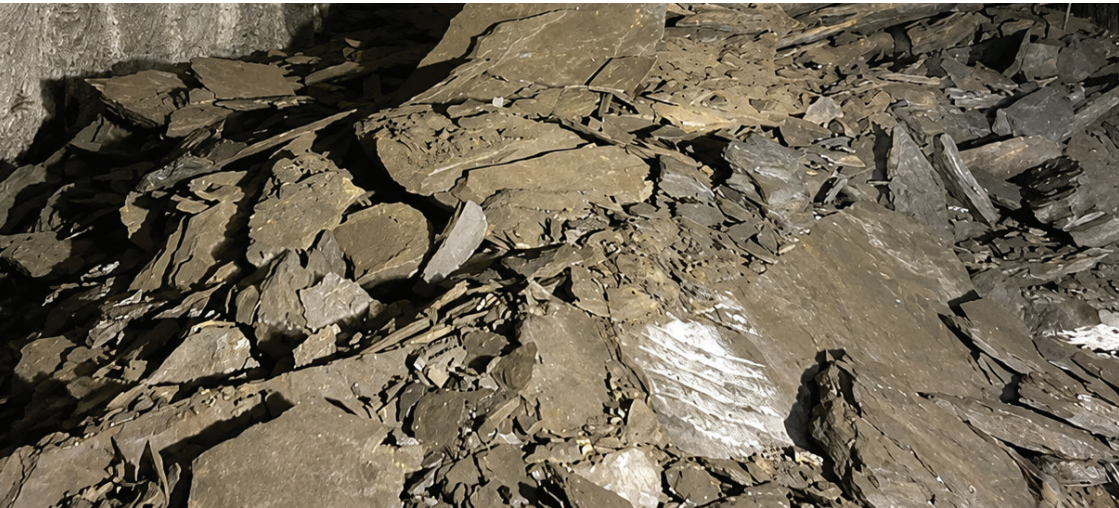
By partially replacing conventional materials such as cement, gravel and sand in selected road layers and surfacing applications, coal ash can help lower construction costs, reduce pressure on natural material sources and minimise the environmental burden associated with landfill disposal.



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Safer and more productive mining through alternative stress measurement methods

The stress measurement method being trialled by the CSIR is an alternative approach to estimating the magnitude and orientations of the major original field stress components, to support safer, more productive underground mining.

Many of South Africa's major ore bodies are underground, with some of these operations among the deepest in the world, reaching 3-4 km below the surface. As mines locally and globally move deeper to access minerals such as copper, platinum, gold and nickel, the in-situ stress field components play an increasing role in excavation stability.

Reliable and regular field stress measurement will assist geotechnical and mining engineers to design

stable excavations and plan safe mining sequences that protect people, equipment and production.

Originally developed by Japanese researchers for seismic activity studies, this alternative approach promises to be more practical and cost-effective in the field than conventional methods.

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Untreated coal waste in asphalt: from waste challenge to engineered opportunity

The CSIR has completed laboratory-scale work demonstrating the potential to repurpose untreated coal waste in road construction. This innovation addresses the environmental risks associated with large waste volumes stored in waste dumps and landfills, including impacts on land, water and surrounding communities. By redirecting waste to productive use, we help transform a persistent waste challenge into a practical materials opportunity for the transport sector.

Advanced laboratory testing that underpins industry confidence

Our Advanced Materials Testing Laboratory provides comprehensive characterisation and performance testing for unclassified coal fly ash

and other non-traditional materials. The facility also conducts specialised tests on soils, aggregates, bitumen, coal-waste asphalt mixes and concrete, enabling benchmarking, product optimisation and the development of performance-compliant road construction materials.

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Helping turn circular-economy ambition into practical outcomes by enabling the responsible, performance-based reuse of coal-derived materials.

Value creation across sectors

Repurposing coal ash can support sustainability, job creation, localisation and skills transfer across multiple industries. It also opens opportunities for new products, services and supply chains linked to sustainable infrastructure delivery.

Although coal ash is typically classified as waste, its mechanical and chemical properties make it a valuable resource for innovative applications, including road construction materials designed for performance, practicality and scale.

Fly ash, which makes up the bulk of coal ash generated during power production, has properties that support its use in construction products and transport infrastructure. Beyond road applications, it can add value in concrete-based systems used for roads, bridges and buildings.

Delivering sustainability with practical outcomes

Coal ash is a by-product of electricity generation, but with the right science and engineering, it can become part of a more sustainable infrastructure future. It is helping to turn the circular-economy ambition into practical outcomes by enabling the responsible, performance-based reuse of coal-derived materials.

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