INNOVATIONS IN SUSTAINABLE MORTARS – GEOPOLYMERS

SCOTT DISTEFANO, SR. PRODUCT MANAGER

MAY 14, 2024

BUILDING TRUST

SUSTAINABLE MORTARS

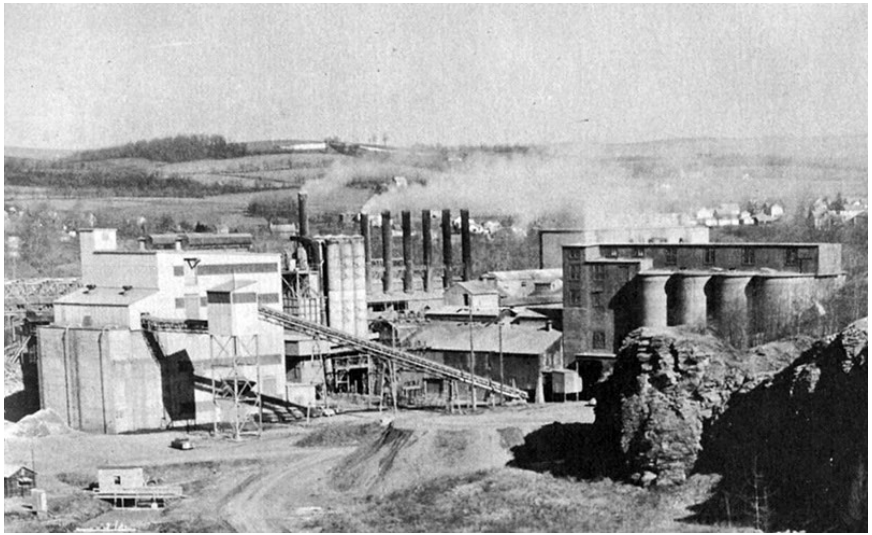
OVERVIEW

- Why ***sustainable*** mortars?
- What is ***Geopolymer***?
- New products:
  - **Sika MonoTop®-4500 GeoHybrid**
  - **SikaCrete®-6000 GeoHybrid**

SUSTAINABLE MORTARS

WHAT IS SUSTAINABILITY AND WHY IS IT IMPORTANT?

- Sustainability, reuced carbon footprint, green are heard every day in the news cycle
- Concrete and most concrete repair materials are based on Portland cement
- Portland cement production accounts for 8% of global CO_2 emissions*
- 1 ton of cement products results in ~1 ton of CO_2 emissions+

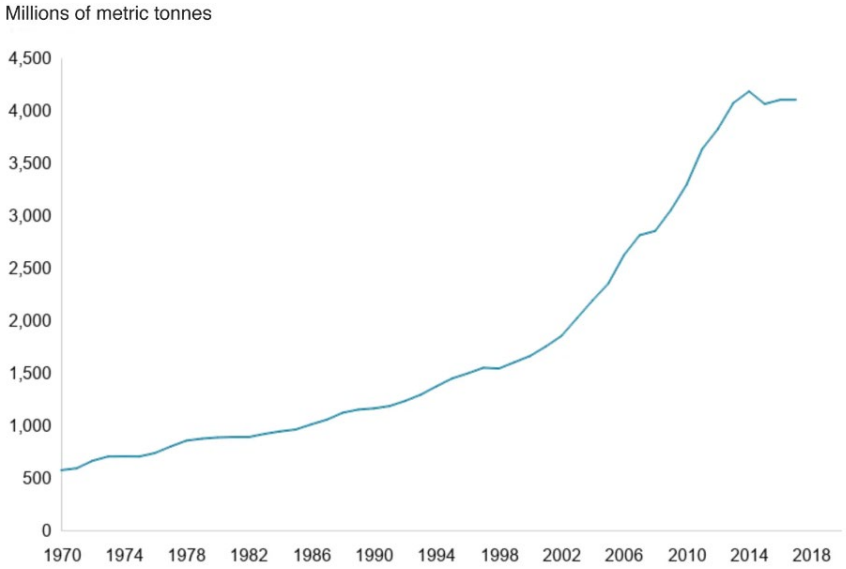


* Ref: Chatham House
\+ Ref: Scientific American, 2023

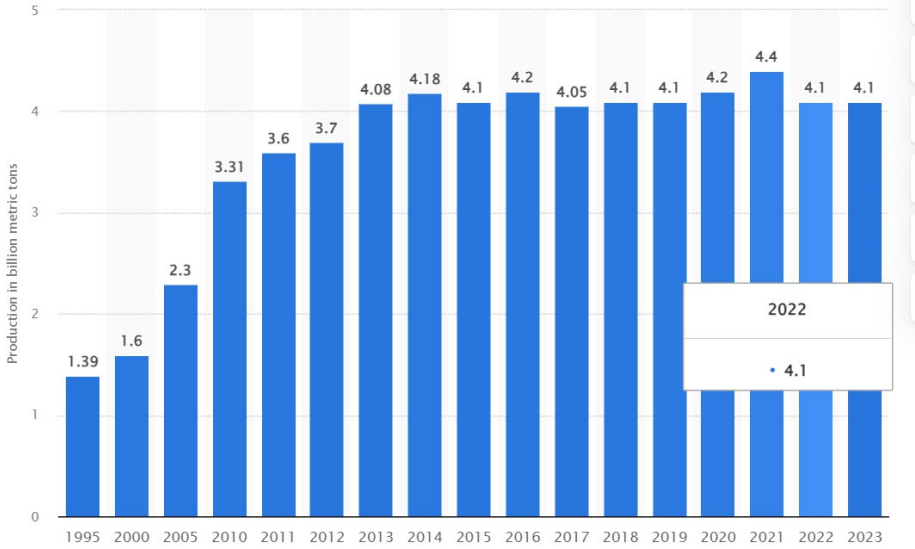
SUSTAINABLE MORTARS

GLOBAL PORTLAND CEMENT PRODUCTION VOLUME

- Production has leveled off since 2013, likely the result of increased use of SCM’s



Ref: Mohr, *et.al* (2015)



Ref: Statistica

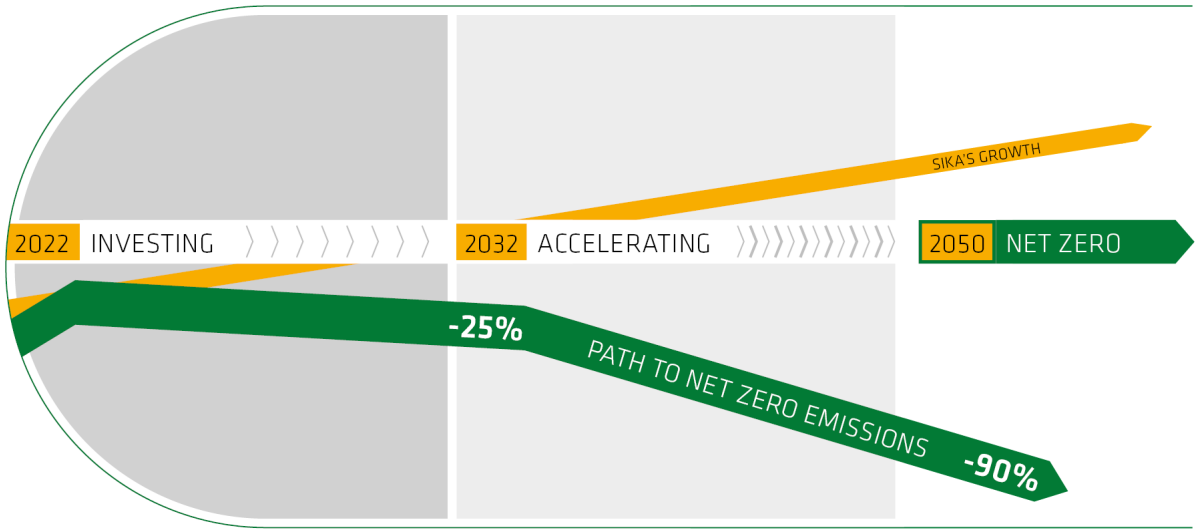
SUSTAINABLE MORTARS

GLOBAL PORTLAND CEMENT PRODUCTION VOLUME

- Even with Portland cement production leveling off …
  - 4 Billion metric tons of Portland cement results in 4 Billion metric tons of CO_2!

INNOVATION & SUSTAINABILITY – STRATEGIC PILLARS 2028

SIKA'S NET ZERO PATHWAY – DRIVING THE TRANSFORMATION



OUR KEY LEVERS

Education and capacity building to improve **material efficiency and circularity**

Accelerated use of **alternative low carbon supplies**

Continued focus on **operational efficiencies**

Partnerships with key suppliers who support Sika's path to net zero

Development of **new innovative solutions** for construction and industry

INNOVATION & SUSTAINABILITY
SUSTAINABILITY PORTFOLIO MANAGEMENT (SPM)

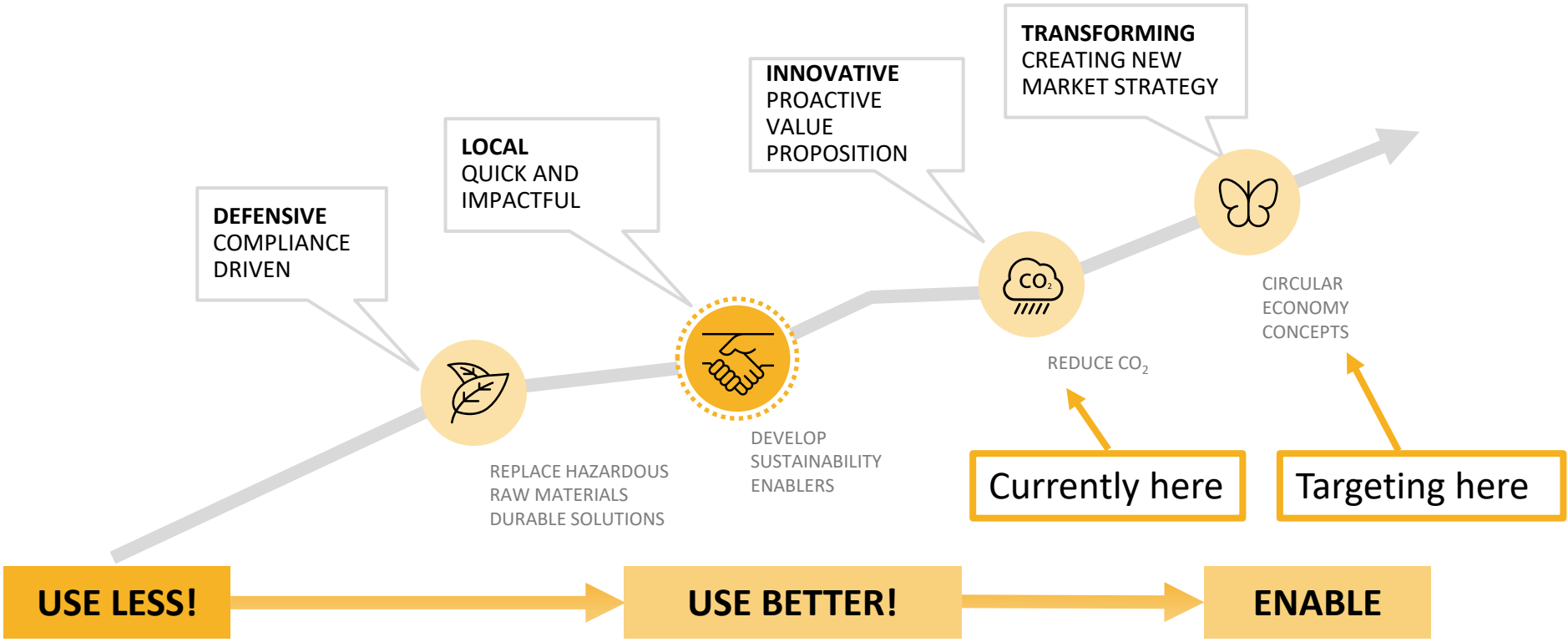
All new product developments to be SPM validated with a positive validation

MORE **PERFORMANCE**
MORE **SUSTAINABLE**

SPM | Sustainability Portfolio Management

- The SPM evaluates solutions based on **12 sustainability** and **6 performance categories.**
- SPM is used to classify, and **market sustainable solutions.**
- Sika's goal is to manage innovation and sustainability, **minimizing risks and maximizing opportunities**.
- Sika is the 1st company within the specialty chemicals and building materials sector to develop and implement the **SPM Concept** based on the World Business Council of Sustainable Development framework.

INNOVATION & SUSTAINABILITY – ROADMAP MERGE
DURABILITY, DECARBONIZATION, AND CIRCULARITY



GEOPOLYMER
WHAT IS A GEOPOLYMER?

- Geopolymer – Portland cement-free binder
- “Geopolymerization” coined by Joseph Davidovits in the later 1970’s
- Class of inorganic, polymeric materials that form different chemical units of silicates and aluminosilicates … similar to Portland cement.
- Showed promise as a low/no CO_2 alternative to Portland cement
- Limitations as a result of scale-up and acceptance

In the late 1970’s, Joseph Davidovits, the inventor and developer of geopolymerization, coined the term “geopolymer” to classify the newly discovered geosynthesis that produces inorganic polymeric materials now used for a number of industrial applications. He also set a logical scientific terminology based on different chemical units, essentially for silicate and aluminosilicate materials, classified according to the Si:Al atomic ratio:

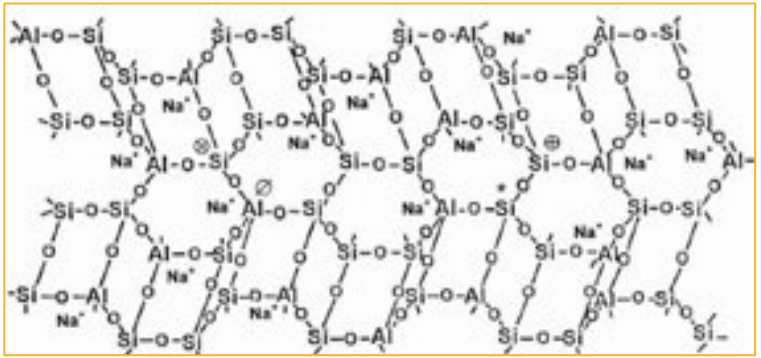
Si:Al = 0, siloxo

Si:Al = 1, sialate (acronym for silicon-oxo-aluminate of Na, K, Ca, Li)

Si:Al = 2, sialate-siloxo

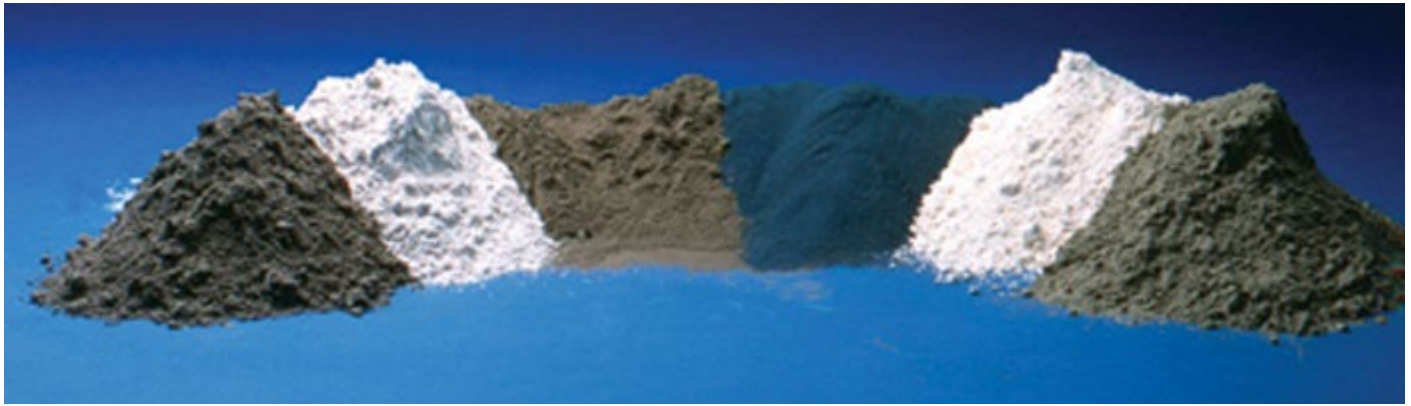
Si:Al = 3, sialate-disiloxo

Si:Al > 3, sialate link.



GEOHYBRID
WHAT IS MEANT BY GEOHYBRID?

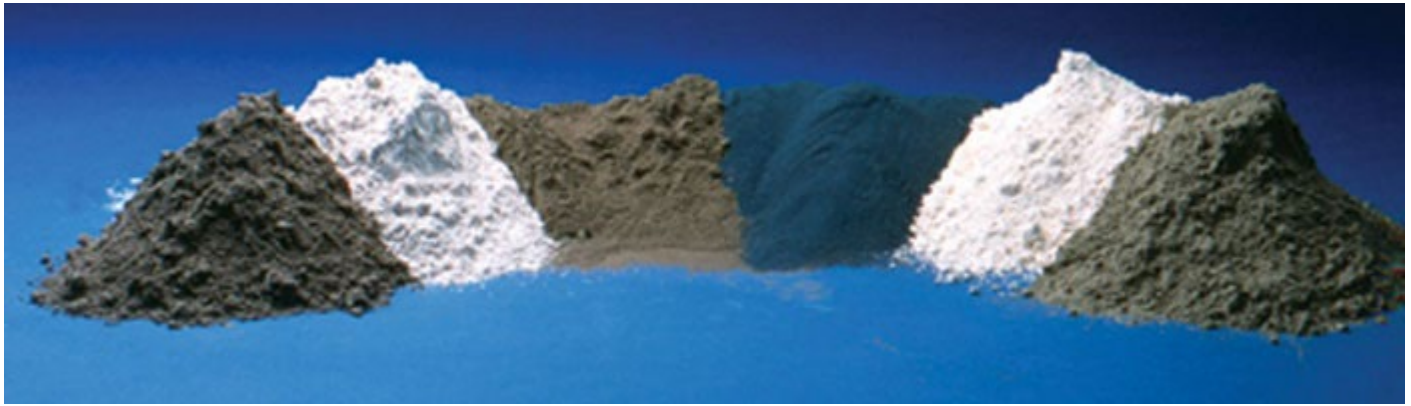
- Geopolymer – like
- Utilizes supplementary cementitious materials (SCM's)
- Aligns with global Sika sustainability vision
- Carbon footprint greatly reduced vs. traditional repair mortars (20-50%)



Ref: Portland Cement Association

GEOHYBRID
WHAT ARE SCM'S?

- Fly ash (Class F, C)
- Ground, granulated blast furnace slag
- Silica fume (condensed)
- Metakaolin (calcined clay)
- Rice hush ash
- Bottom ash



Ref: Portland Cement Association

GEOPOLYMER
HOW DO SCM'S WORK?

- The calcium silicates in Portland cement react with water to form hardened cement paste (sometimes called "gel")

$$C_3S + H_2O \rightarrow \text{C-S-H gel} + CH$$

- CH (calcium hydroxide is a by-product of the reaction, provides no strength and results in porosity

$$SCM + CH + H_2O \rightarrow \text{C-S-H gel}$$

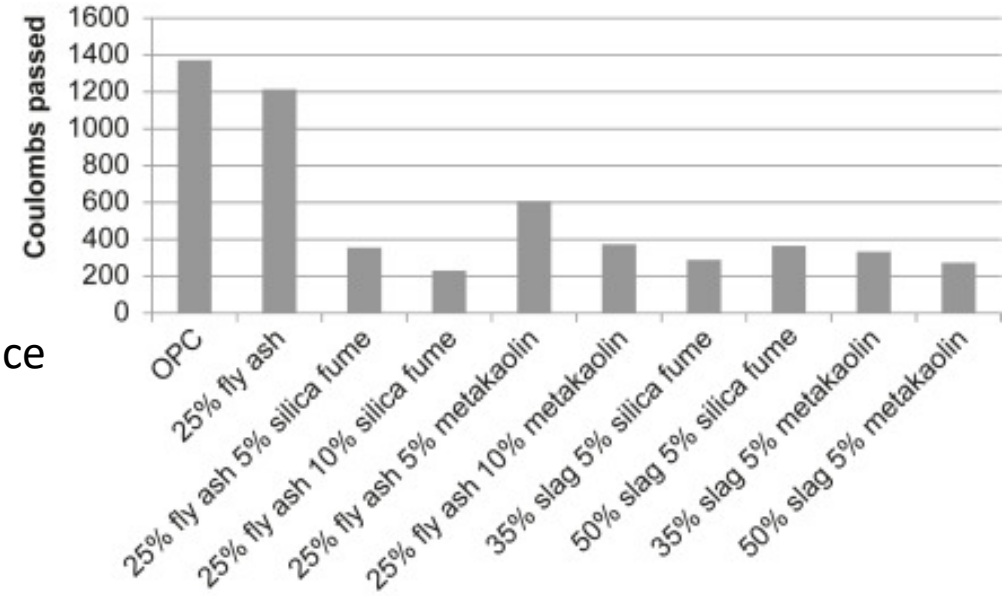
- SCM's react with water and CH to form more "gel" in to micropores, resulting in lower permeability and increased late-age strength

GEOHYBRID

BENEFITS OF GEOHYBRID TECHNOLOGY VS. PORTLAND CEMENT

- Lower permeability
  - Longer service life
- Lower exotherm
  - Deeper applications
- Improved chemical resistance
- Higher in-service temperature resistance
- Longer shelf-life

ASTM C 1202 – Rapid Chloride Permeability



ASTM C 1202 Results (56 days) – Holland (2102)

GEOHYBRID

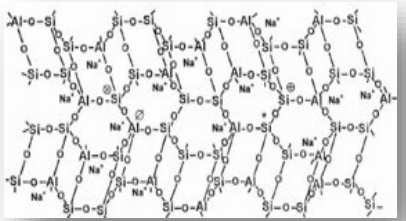
CHALLENGES WITH SCM'S REPLACEMENT OF PORTLAND CEMENT

- Poor early-age strength development
  - Remember: Portland cement must first react with water for the calcium hydroxide (by product) to form
- Not rapid set
- Very slow or no cure at cold temperatures

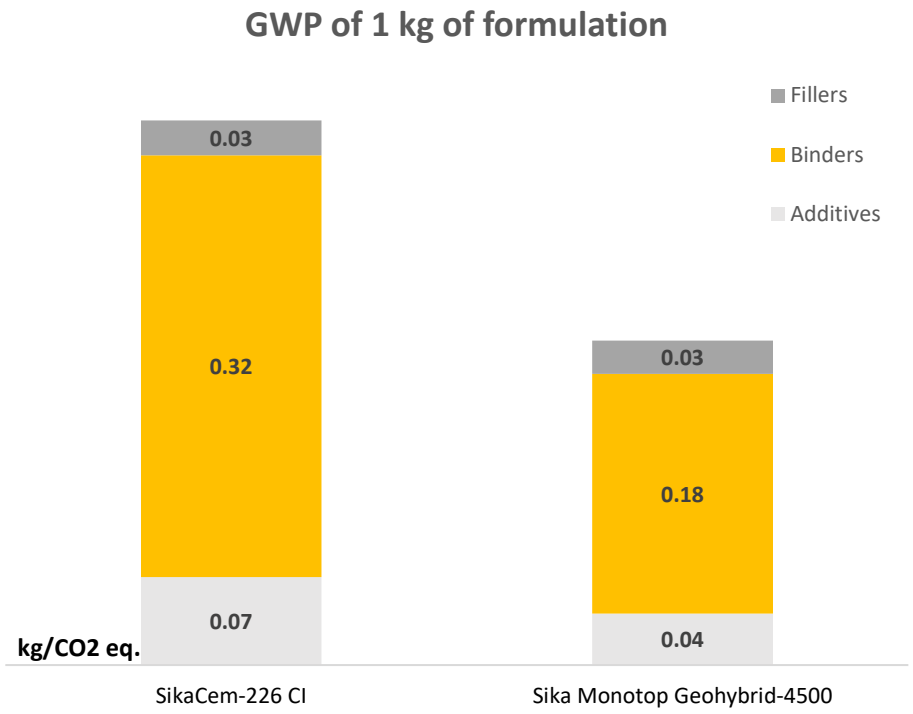
GEOHYBRID

INTRO TO TECHNOLOGY

- Sika Monotop®-4500 Geo Hybrid is a new cementitious mortar based on Geo Hybrid binder technology rather than OPC
- Geo Hybrid polymers are an alkali-activated, alumino-silicate binder with high mechanical and durability properties
- Concrete repair product which can be used in several different applications
- A sustainable alternative to OPC



GEOHYBRID
CO_2 FOOTPRINT CALCULATION



Reduction of Portland cement by > 25% and addition of SCM's

40% REDUCTION IN GWP WHEN COMPARED TO SIKACEM-226 CI

NEW GEOHYBRID PRODUCTS

- Sika MonoTop®-4500 GeoHybrid
  - Geopolymer vertical / overhead
  - Spray applications
    - Up to 3” vertical in one application
    - 1” overhead without reinforcement
  - Excellent chemical resistance (H_2S)
    - Waste water applications
  - Can be used for horizontal applications w/ higher H_2O

NEW GEOHYBRID PRODUCTS

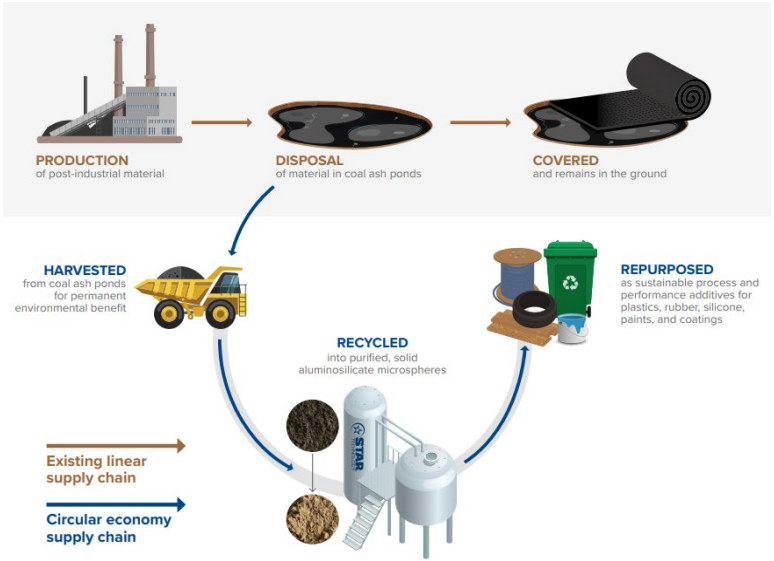
- SikaCrete®-6000 GeoHybrid
  - Geopolymer micro-concrete
  - Formulated with 3/8” pea gravel
  - SCC formulation
  - Low permeability
  - Excellent freeze-thaw durability
  - Improved chemical resistance
  - Deep pour applications (up to 12”)

OTHER SUSTAINABLE INITIATIVES

- Circular economy
  - Current industrial model - resources are mined, made into products, and then become waste.
  - A circular economy reduces material use, redesigns materials and products to be less resource intensive, and recaptures “waste” as a resource to manufacture new materials and products.
- Sustainable packaging
  - Recyclable PET or HDPE plastics, cardboard, and paper, which can be reprocessed into new items
  - Also includes compostable materials such as PLA (starch-based) and cellulose, which biodegrade in compost, offering an eco-friendly alternative to traditional plastics.

CIRCULAR ECONOMY - EXAMPLE

- EPA Superfund site – Government declared remediation
- Coal Combustion Residuals (CCR)
  - ***Using "buried" fly ash in new products***



SUSTAINABLE PACKAGING

RECYCLABILITY: The paper coated with this resin is recyclable and repulpable, without generating residues during the process.

It is necessary for the parings to go through a process of "removing mortar residues" before proceeding to the recycling process.

CIRCULAR ECONOMY: Mono-material packaging increases efficiency and reduces the costs of post-consumer packaging recycling processes, which can be used as a raw material for the production of recycled papers.

LESS PLASTIC: Reduction in the use of plastic films and fossil source materials.

The mortar bags packaging are made by resin paper, using specific resins and creating water vapor barrier (WVTR < 300 [g .H2O/m².24hs] [38°C/90%RH]) at the inner layer.

This protection allows the use of mortar packaging papers, keeping the bagged product free from moisture absorption.

The resins used are an aqueous dispersion of polymers and special additives, totally free of fluorine.

SUMMARY

- Portland cement production accounts for 8% of global CO_2 emissions
- Novel building materials with less or no Portland cement are needed
- Geopolymers or GeoHybrid materials drive Sika and the industry toward meeting cabon footprints and reduced emission goals
- Sika Monotop® 4500 GeoHybrid and Sikacrete® 6000 GeoHybrid offer exciting technology with a reduced carbon footprint *and* unique value propositions
- Reducing greenhouse gases involved more than products
  - Circular economy and sustainable packaging further reduce emissions through re-use and less waste

INNOVATIONS IN SUSTAINABLE MORTARS – GEOPOLYMERS

SCOTT DISTEFANO, SR. PRODUCT MANAGER

MAY 14, 2024

BUILDING TRUST