



U.S. Department of Energy Cement & Lime Decarbonization Workshop

Session 4 - Alternative Binders and New SCMs

Ecocem ACT for 50-70% Reduction in Embodied Carbon

S4: Alternative Binders and New SCMs

Ecocem Materials Ltd



Ecocem was established in 2000, grown to > 180 employees and four production facilities across western Europe.



Manufactures 2.4 million tons of low carbon cement per year, including Europe's lowest carbon cements, AAC, SSC; used in Europe's most important infrastructure projects.



>16 million tons of CO₂ have been prevented from entering the atmosphere using Ecocem products.



Over 2% of annual revenues are invested in R&D (>USD 25 million), much higher than any European cement company; the innovation team has 39 team members, incl. 27 PhDs.



Saint-Gobain (parent of GCP and Chryso) and Ecocem announced a partnership to fast-track new low carbon cement technology as a mass market solution in October 2022.



Breakthrough Energy Ventures is a partner since 2021. Objective: Ecocem technologies to **reduce CO₂ emissions from cement globally by over 500 million tons per year**



Ecocem GGBS Facility Planned for Port of Los Angeles -2025/2026

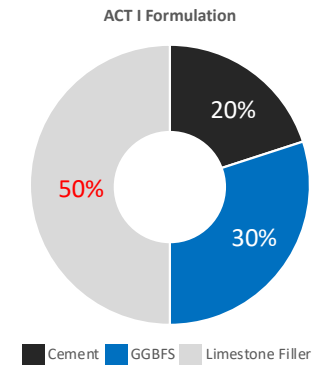
S4: Alternative Binders and New SCMs

Ecocem ACT, High Filler Low Water

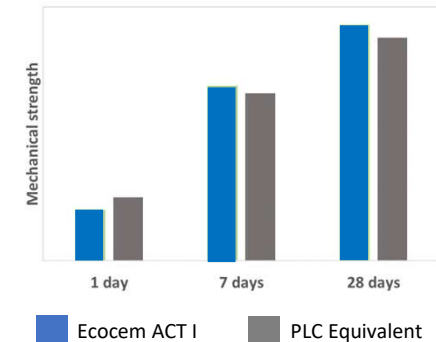


Ecocem ACT - novel cement technology w/50% limestone filler can meet **ASTM C1157** Cement Performance Specification

- ✓ Nominal **50% limestone filler** by design
- ✓ Balance is combination of SCM and OPC
- ✓ Formulations vary based on available raw materials
- ✓ **Engineered PSDs** for each component material
- ✓ Innovative, complementary superplasticizers
- ✓ **Field tested in ready mixed concrete operations**



Concrete for 50 Mpa (7250 psi) at 28 days		
Binder	Ecocem ACT I	PLC equivalent (CEM II/A L)
Total Binder Content (kg/m ³)	300 - 350	275 - 300
Reactive Binder Content (kg/m ³)	150-175	256-279
Binder Intensity (kg/m ³ * MPa)	2.8 - 3.3	4.8-5.3
CO ₂ Footprint (kg CO ₂ / t of cement)	~185	~630



Ecocem ACT : 50-70% Reduction in Embodied Carbon in Concrete



*Decarbonizing Cement and Concrete Value Chains: Takeaways from Davos** (McKinsey)

Levers to decarbonize along the value chain

1. Reducing ...clinker in cement

- ❑ *substituting clinker with alternative materials...*
- ❑ *reducing the amount of clinker needed via innovations in construction, design, material mixes...*

2. Reducing the CO₂ from energy used in the production process...

3. Storing or utilizing remaining CO₂ emissions...

McKinsey
& Company

Priority Considerations for Ecocem R&D toward Decarbonizing the Cement and Concrete Sector, solution should be:

- **Scalable** - universally scalable, **all concrete, everywhere**; reduce 500,000,000 tpy CO₂ at scale (BEV)
- **Quicky Deployable** - urgency to halve emissions by 2030 (IPCC report, *Climate Change 2022*)
- **Cost Effective** - incentivizes widespread adoption (via licensing, non-exclusive)
- **Minimize Barriers to Entry** - compatible w/existing industry infrastructure



Ecocem R&D Priority: Cost Effective... Focus on Carbon Avoidance (CA) over Carbon Usage (CU)



High-Filler, Low-Water Cement (HFLW) and Concrete Technologies, R&D progress for over 10 years

Government R&D toward HFLW: NIST (2009, 2016), ORNL (2023), DOE-ORNL (2022-2025)

University R&D on HFLW: University of São Paulo (BR), Universität Darmstadt (DE), KTH-CBI (SE), KIT (DE), Aalto University (FI), Oregon State (US), UT-Knoxville (US), recently multiple other Ecocem sponsored university R&D projects

Private R&D on HFLW: Ecocem, VDZ (Germany's "PCA"), numerous other cement and technology companies

VDZ (2014)* *"...sophisticated process engineering measures in the cement plant...equally sophisticated concrete technology measures in the concrete production would be necessary for the production and use of high-limestone cements (up to 50 mass % LL (limestone)). If these measures can be implemented under practical conditions then it will be possible for the concrete to achieve durability parameters that can meet the approval requirements."*

Ecocem's targeted R&D project considerations

- ✓ R&D Basis - GGBFS & more reactive SCMs are limited in supply, leverage their value for further clinker factor reduction
- ✓ Use readily available, abundant mineral fillers to replace clinker
- ✓ Compensate for strength loss from high filler content with low water content in concrete
- ✓ Note the major industry obstacle has been workability in commercial ready mixed concrete

HFLW Cements/Concrete Will Meet Performance Requirements - Missing Link Has Been "Workability"

U.S. Department of Energy Cement & Lime Decarbonization Workshop - Canonsburg PA, 19 – 20 July 2023

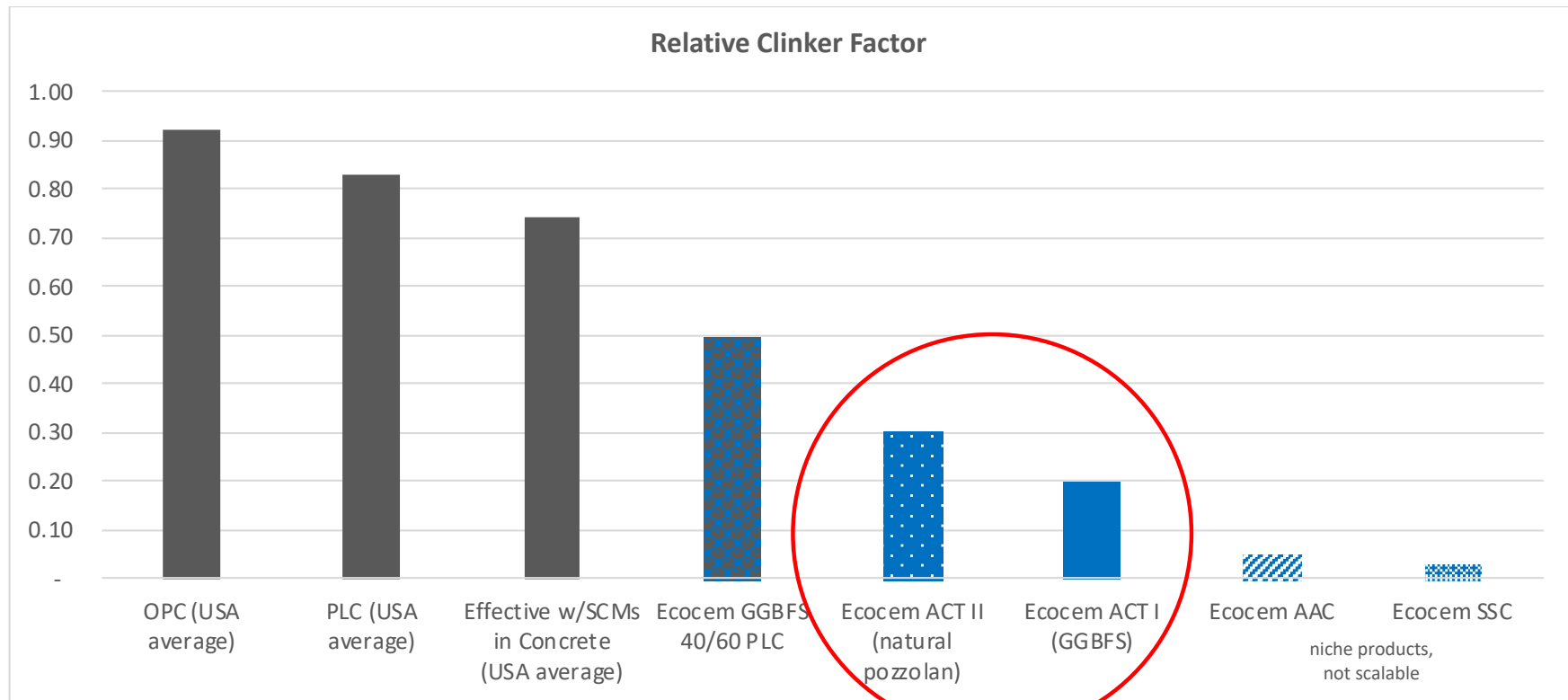
* Müller, C. & Palm, S. & Graubner, C. & Proske, T. & Hainer, S. & Rezvani, M. & Neufert, W. & Reuken, I.. (2014). Cements with a high limestone content - Durability and practicability. Cement International. 12. 78-85.

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Ecocem ACT - novel cement technology w/50% limestone filler can meet ASTM C1157 Cement Performance Specification



Ecocem ACT : 50-70% Reduction in Embodied Carbon in Concrete

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Nominal 50% limestone filler; balance is SCM/OPC

- **activation technologies required for non-GGBFS SCMs**

Formulations vary based on available raw materials

- ACT II (using natural pozzolan) is 30% OPC / 20% POZ

Engineered PSDs for each component material

- **Separate grinding of components, blending of components, higher kWh/t total In finish mill grinding**
- **50-70% of limestone bypasses kiln, commensurate reduction in calcination/thermal CO₂, SO₂, NO_x, mercury**

Innovative, complementary superplasticizers in combination with the prescribed PSDs achieves the target “workability”

Workability - not well defined by ASTM tests

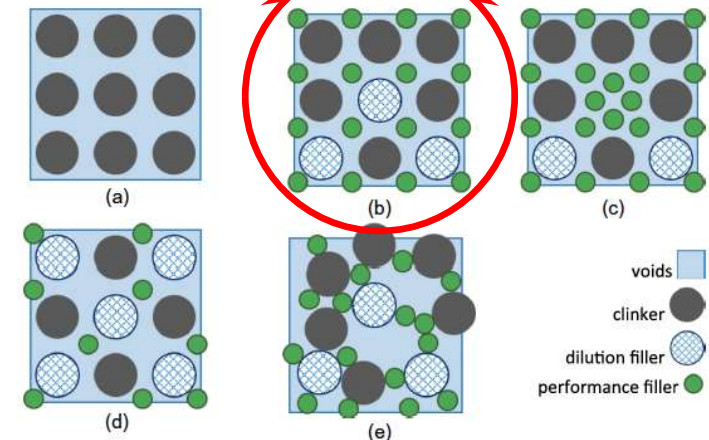
Workability is combination of two (2) characteristics:

- yield stress, correlated w/ASTM C443, slump cone test
- plastic viscosity, **not** well correlated w/ASTM C443

“...The new technology, high filler content compensated by a reduction of mixing water demand by packing and dispersion...”*

Ecocem ACT: Engineered particle size distribution (PSD) of components

Ecocem ACT: Innovative, complementary superplasticizers



water:cement ratio 0.30-0.35



Timing (Ecocem Europe)

Product certification due in 2023 (EU does not have a cement performance specification like ASTM C1157);

Ecocem ACT pilot production facility to be commissioned in late 2023;

Agreements in place for limestone filler facility at commercial scale production by 2025, production of ACT I;

Multi-application/multi-market demonstration program underway in Western EU markets, full market access by 2026.

Timing (Ecocem Americas)

Pursuing funding for Demonstration Project w/Pilot Plant (2-3 years to complete), includes:

- Localization of several formulations with local raw materials, tested according to ASTM C1157 standards;
- Documentation of scalable pilot process technology (improve estimates of CapEx, OpEx, EPD values by location);
- Validation of performance in commercial ready mixed concrete operations;
- Confirmation of strength and durability performance.

Barriers/Critical Path Items

- **DoTs' validation and authorization for use (3-5 years)**
- **Installation of ultrafine grinding capacity for select components (3-7 years)**

ECOCEM ACT - DECARBONIZE FURTHER, FASTER, FOR LESS



Thank you Questions?

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Background
Decarbonization

Cost Effective

Workability

Strength

Durability

19-20 July 2023