



The Future of Cement: Integrating Supplementary Cementitious Materials (SCMs) from a Plant Perspective

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Why is this Change Happening Now?



Economic Viability: Reducing production costs to increase profits and remain competitive.



Environmental Requirements: Lowering the quantity of emissions per ton of product and conserving natural resources.



Market Demands: Continued growing demand for cement material, backed by further adoption of different cement products



Economic Viability and Market Demand

- **Increased Production Capacity:** Produce more finished product with the same amount of clinker.
- **Reduced Fuel Consumption:** Reducing the total amount of clinker per ton of product reduces overall fuel consumption.
- **Lower Raw Material Costs:** SCMs like limestone or industrial by-products are often significantly cheaper than quarrying and processing primary raw materials.
- **Extended Quarry Life:** By reducing the amount of clinker required per ton of product, you extend the operational life of your existing quarries.



Environmental Requirements

- **Lower Emissions:** The calcination process to create clinker releases vast amounts of CO₂.
- **Conservation of Natural Resources:** Decreases the reliance on virgin materials like limestone, clay, and shale.
- **Reduced Energy Footprint:** Lower grinding and kiln energy requirements lead to a significant decrease in overall energy consumption per ton of cement produced.



What are Supplementary Cementitious Materials (SCMs)?

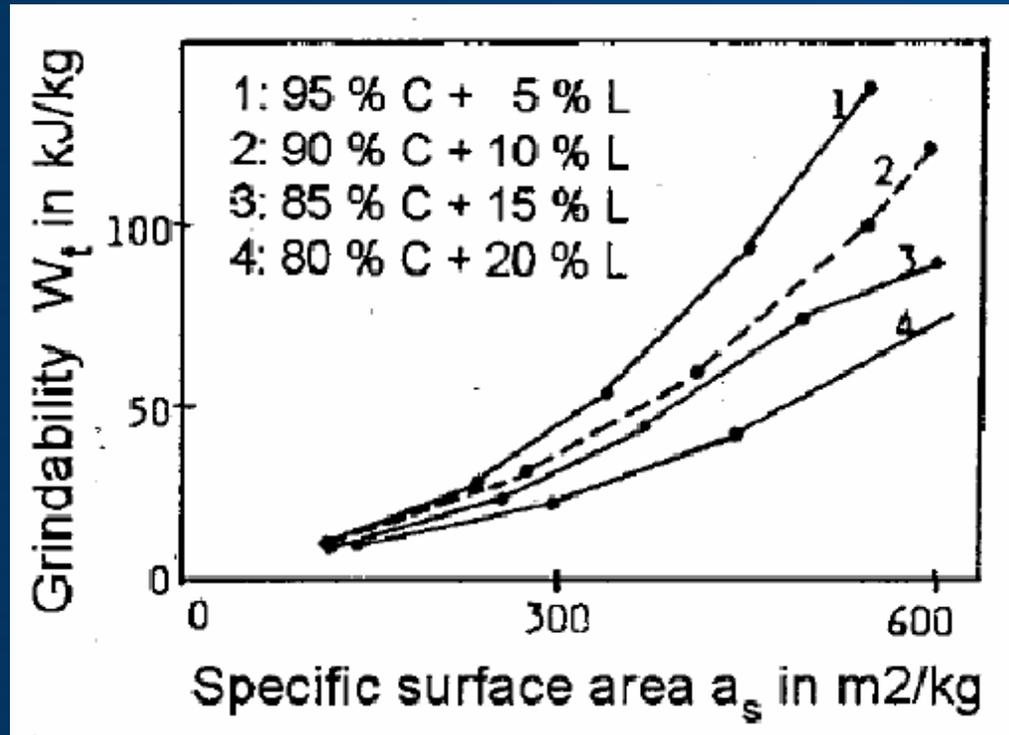
SCMs are finely-ground siliceous or pozzolanic materials that are added to cement to enhance its properties, reduce cost, and lower its environmental impact. They work by reacting with the by-products of cement hydration to form additional cementitious compounds.

Common SCMs Discussed:

- **Limestone:** A readily available and widely adopted supplemented material.
- **Calcined Clay:** An emerging, highly reactive pozzolan with excellent performance characteristics.
- **Other Materials:** Fly ash, slag, and natural pozzolans.



Limestone – Type IL



Type IL cement is a blended cement defined by ASTM C595, containing between 5% and 15% finely ground limestone.

- **Performance and Adoption:** Provides a similar performance to OPC, allowing for easier adoption.
- **Primary Benefit:** Directly reduces the clinker factor, lowering the overall emissions, fuel consumption, and power consumption per ton of product.
- **Finish Grinding:** The soft material benefits specific power consumption and increases throughput. Existing equipment must be able to handle additional throughput (bucket elevators, airslides, separator)



Fly Ash



Fly ash has been a cornerstone SCM for decades, valued for its performance-enhancing properties.

- **Source:** A by-product collected from the exhaust gases of coal-fired power plants.
- **Type:** A pozzolanic material that reacts with calcium hydroxide.
- **Key Benefits:** Improves concrete workability, reduced water demand, and increases late-day strength
- **Plant Challenge - Availability & Quality:** With the global decline of coal power, sourcing consistent, high-quality (low-carbon, low-alkali) fly ash is becoming a major industry challenge.



Slag

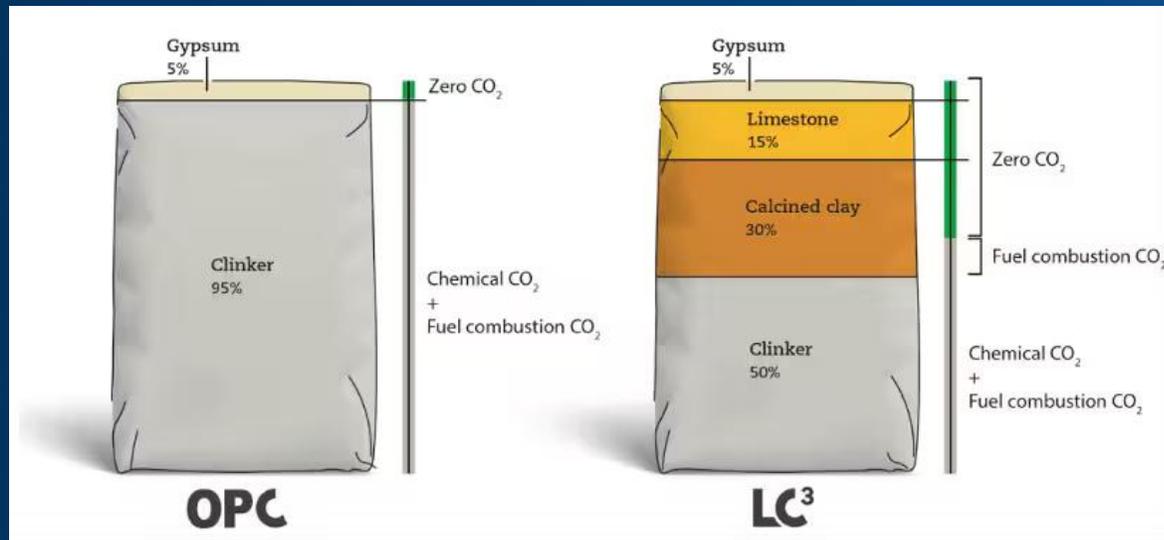
Slag is a highly effective SCM, particularly for high-performance and specialty applications.

- **Source:** A by-product of iron manufacturing.
- **Type:** A pozzolanic material that reacts with calcium hydroxide.
- **Key Benefits:** Improves concrete durability (specifically from thermal stress) and enhanced late-day strengths.
- **Plant Challenge - Grindability:** Slag is typically harder to grind than clinker, which can increase specific energy consumption (kWh/ton) and potentially lower mill output when interground.



Calcined Clay – LC3

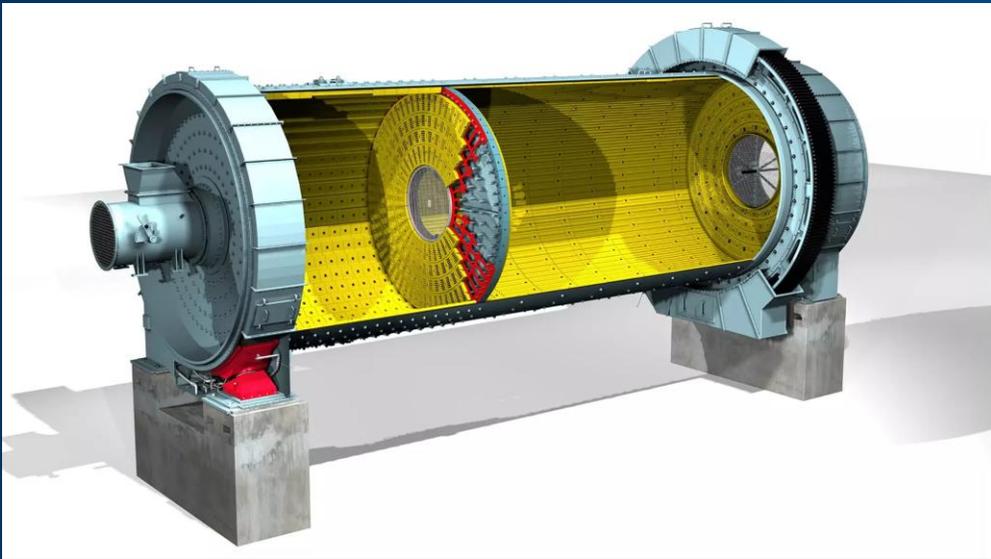
Calcined clay is produced by heating common kaolinite clays to 700-850°C, a much lower temperature than clinker production. This process transforms the inert clay into a highly reactive pozzolan.



- **What is LC3?** A blended cement, similar to type II, composed of roughly 50% clinker, 30% calcined clay, 15% limestone, and 5% gypsum.
- **Massive CO₂ and Fuel Reduction:** By cutting the clinker factor to 50%, LC3 can reduce CO₂ emissions and specific fuel consumption significantly compared to traditional cement.



Integration into Existing Plants



There are two principal methods for introducing SCMs into the cement manufacturing process. The choice between them depends on plant layout, material characteristics, and production goals.

- **Intergrinding:** SCMs are ground together with clinker and gypsum in the finish mill.
- **Separate Grinding & Blending:** SCMs are ground separately and then blended with finely ground cement and gypsum.



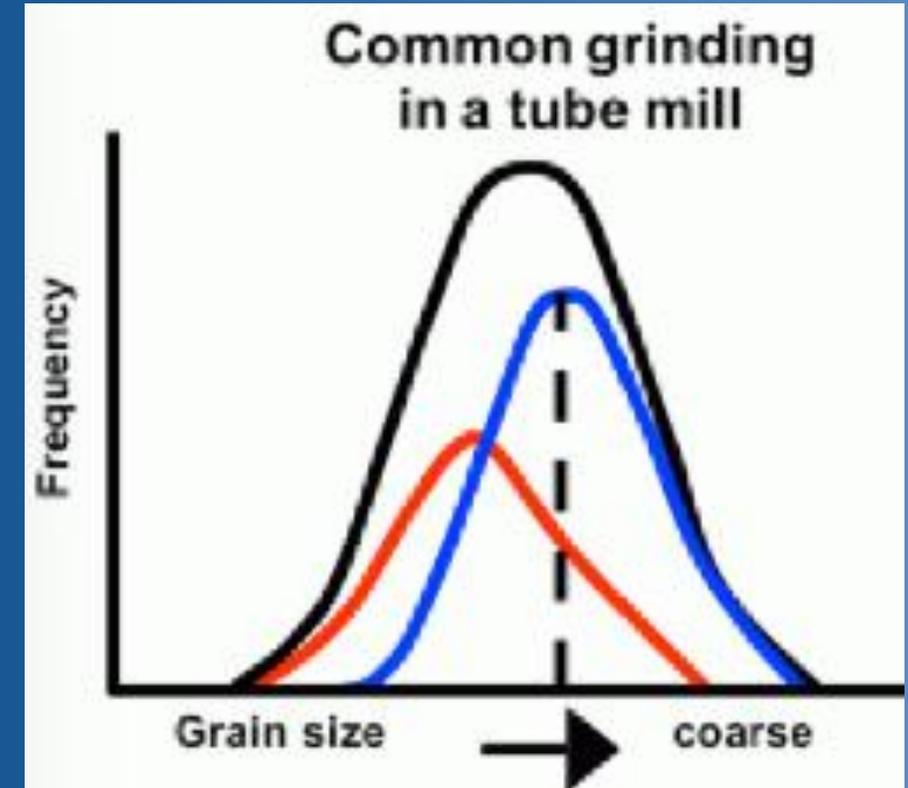
Advantages and Disadvantages of Intergrinding

Advantages:

- **Lower Initial Capital Cost:** No need to invest in a separate grinding circuit for the SCM.
- **Simplified Logistics:** Fewer material transfer and storage steps compared to a separate blending system.

Disadvantages/Challenges:

- **Grinding Inefficiency:** Different materials have different grindabilities. Harder clinker may not be ground as finely if a softer SCM is present, potentially affecting strength development.
- **Moisture Sensitivity:** High-moisture SCMs can lead to "ball coating" and reduced grinding efficiency in the mill.



Advantages and Disadvantages of Separate Grinding

Advantages:

- **Optimized Grinding:** Each material (clinker and SCM) can be ground to its optimal fineness, maximizing performance and energy efficiency.
- **Improved Quality Control:** Fineness and composition of each component can be precisely controlled before blending, leading to a highly consistent final product.

Disadvantages/Challenges:

- **Higher Capital Investment:** Requires significant upfront cost for a separate grinding circuit, storage silos, and a blending system.
- **Increased Complexity:** More complex material handling, storage, and process control systems are needed.
- **Larger Plant Footprint:** The additional equipment requires more physical space on site.



Ultrafine Limestone (UFL) – Case Study

- A plant currently sources a pre-sized limestone material that can be fed into the finish mill.
- They can utilize their own limestone material for much cheaper, but it would need to be reduced further after their primary crusher.
- The plant is bottlenecked by their finish mill system. The raw mill has about 20 hours a week of available runtime based on their current capacity.

How can the plant utilize the existing equipment to feature a cheaper limestone material for production of Type IL, while increasing finish mill production, and is it economically feasible?



Ultrafine Limestone (UFL) - Solution

- The plant can process the limestone in the available time of the raw mill to a finish product size, also allowing for drying of the raw material.
- The price of additional/upgraded equipment can be justified through savings on material costs and production increases.
- The fine limestone can be injected with the clinker/gypsum mixture after the finish mill to prevent excessive grinding and reduce the specific power consumption of the finish mill product.



Ultrafine Limestone (UFL) - Challenges

Grinding Trials:

- Injection location – Separator Feed, Baghouse Inlet, and Mill Discharge
- Blaine vs PSD – Fineness measurements are critical in assessing the production capabilities.
- Increased throughput on bucket elevator, separator, and reject system. This is mostly due to the reduction in grindability of the clinker/gypsum mixture, requiring a higher circulating factor.



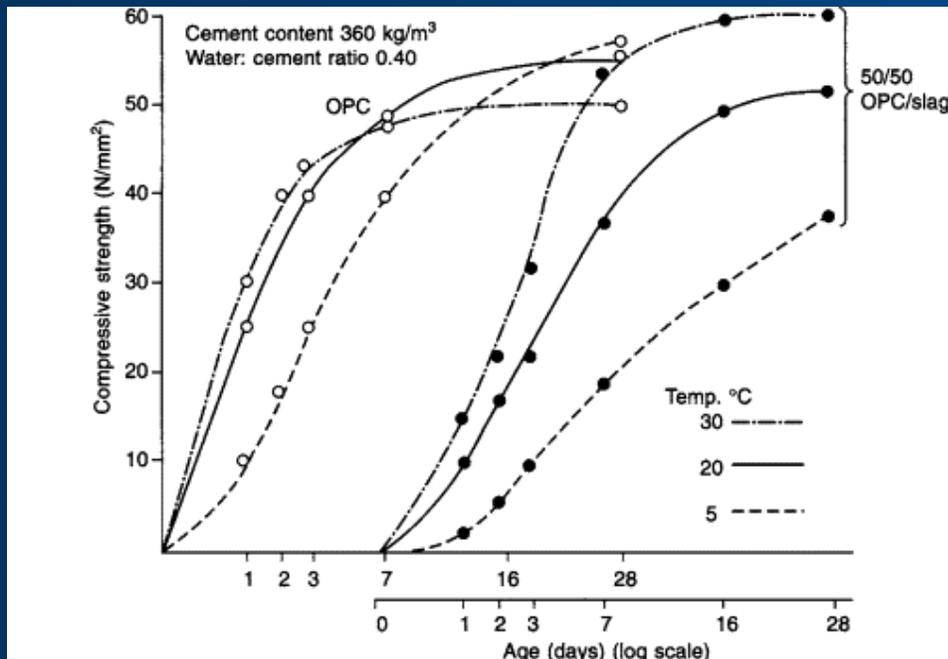
Ultrafine Limestone (UFL) - Conclusion

- Given the fineness targets, the best solution was to inject in combination with the separator feed. This allows for oversized UFL to be ground further in the finish mill and reduces the strain on the limited bucket elevator.
- PSD is a better comparison of fineness from the baseline conditions compared to a UFL-based product.
- Production increase of the finish mill was measured at about 6%, close to our previous calculations.

	Trial - Baseline	Trial - UFL
Production (STPH)	81	86
Production Difference (%)	-	6.17%
Blaine	4310	4396
325 Mesh (% Passing)	99.57%	99.83%
Dv(50) (micron)	11.8	12.1
Rejects (STPH)	173	187



Impact of SCM's on Concrete Application



The use of SCMs alters the final product's performance. Understanding these changes is key for customer acceptance and market success.

- **Water Demand:** Can increase or decrease. Fly ash's spherical particles often reduce water needs. Finer or irregularly shaped SCMs like calcined clay can increase water demand.
- **Setting Time:** SCMs are generally less reactive than clinker, which can lead to slower setting times.
- **Strength Development Profile:** A characteristic trade-off. Early strength is lower while late strength is generally higher due to pozzolanic reactions.



Plant-Level Optimization

Plants can adjust operations to manage the application effects of SCMs and engineer a high-performance, consistent product.

- **Fineness & Particle Size Distribution (PSD):** Grinding blended cement to a higher fineness (higher Blaine) or optimizing the PSD via the separator can significantly boost early-age strength to meet customer needs.
- **Process Control & QC:** Tighter control over SCM quality (e.g., moisture, LOI in fly ash) and precise dosing are critical to minimize variability in the final product.
- **Customer Education:** Proactively communicating the performance characteristics and benefits of blended cements to customers ensures correct application and builds market confidence.



Conclusion

- Partial clinker replacement reduces costs, lowers emissions, extends quarry life, and increases production capacity.
- The primary integration methods are intergrinding and separate blending, each with distinct operational advantages and challenges.
- Successful implementation requires careful management of quality control, material handling, and infrastructure.
- Embracing SCMs may require some additional modifications to the operation to meet customer requirements.



Thank You For Listening!



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