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CEMENT TILE BULK PROPERTY

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FLY ASH IN CEMENT MANUFATURING

By

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Accreditation Number: T1028

KGL

Agenda

- The Effects of Fluctuating Performance in FA
- SABS Auto-Control & Conformity Criteria
- Correlation of Results
- Summary

Fluctuation in Performance of FA

Cement Blending is a Game of Small Margins

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- This not only makes the product more expensive but also produces inconsistent results and variations in the performance of the final product. This adds a layer of complexity to our Conformity Criteria because of the increase in the SD. (*more about that later*)

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- This not only makes the product more expensive but also produces inconsistent results and variations in the performance of the final product. This adds a layer of complexity to our Conformity Criteria because of the increase in the SD. (*more about that later*)
- Improvements in performance can only be picked up after a reasonable number of 28-day results have been acquired, meaning adjustments to the mix design can only be made after app. 38 days. This can lead to an over-performing product at an extra cost.

Table 1 — The 27 products in the family of common cements

Main types	Notation of the 27 products (types of common cement)		Composition (percentage by mass[a])											
			Main constituents											Minor additional constituents
			Clinker	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						natural	natural calcined	siliceous	calca-reous				
			K	S	D[b]	P	Q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95-100	–	–	–	–	–	–	–	–	–	0-5
CEM II	Portland-slag cement	CEM II/A-S	80-94	6-20	–	–	–	–	–	–	–	–	0-5
		CEM II/B-S	65-79	21-35	–	–	–	–	–	–	–	–	0-5
	Portland-silica fume cement	CEM II/A-D	90-94	–	6-10	–	–	–	–	–	–	–	0-5
	Portland-pozzolana cement	CEM II/A-P	80-94	–	–	6-20	–	–	–	–	–	–	0-5
		CEM II/B-P	65-79	–	–	21-35	–	–	–	–	–	–	0-5
		CEM II/A-Q	80-94	–	–	–	6-20	–	–	–	–	–	0-5
		CEM II/B-Q	65-79	–	–	–	21-35	–	–	–	–	–	0-5
	Portland-fly ash cement	CEM II/A-V	80-94	–	–	–	–	6-20	–	–	–	–	0-5
		CEM II/B-V	65-79	–	–	–	–	21-35	–	–	–	–	0-5
		CEM II/A-W	80-94	–	–	–	–	–	6-20	–	–	–	0-5
		CEM II/B-W	65-79	–	–	–	–	–	21-35	–	–	–	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	–	–	–	–	–	–	6-20	–	–	0-5
		CEM II/B-T	65-79	–	–	–	–	–	–	21-35	–	–	0-5
	Portland-limestone cement	CEM II/A-L	80-94	–	–	–	–	–	–	–	6-20	–	0-5
		CEM II/B-L	65-79	–	–	–	–	–	–	–	21-35	–	0-5
		CEM II/A-LL	80-94	–	–	–	–	–	–	–	–	6-20	0-5
		CEM II/B-LL	65-79	–	–	–	–	–	–	–	–	21-35	0-5
	Portland-composite cement[c]	CEM II/A-M	80-88	←—— 12-20 ——→									0-5
		CEM II/B-M	65-79	←—— 21-35 ——→									
CEM III	Blast furnace cement	CEM III/A	35-64	36-65	–	–	–	–	–	–	–	–	0-5
		CEM III/B	20-34	66-80	–	–	–	–	–	–	–	–	0-5
		CEM III/C	5-19	81-95	–	–	–	–	–	–	–	–	0-5
CEM IV	Pozzolanic cement[c]	CEM IV/A	65-89	–	←—— 11-35 ——→					–	–	–	0-5
		CEM IV/B	45-64	–	←—— 36-55 ——→					–	–	–	0-5
CEM V	Composite cement[c]	CEM V/A	40-64	18-30	–	←—— 18-30 ——→			–	–	–	–	0-5
		CEM V/B	20-38	31-49	–	←—— 31-49 ——→			–	–	–	–	0-5

a The values in the table refer to the sum of the main and minor additional constituents.

b The proportion of silica fume is limited to 10 %.

c In Portland-composite cements CEM II/A-M and CEM II/B-M, in pozzolanic cements CEM IV/A and CEM IV/B and in composite cements CEM V/A and CEM V/B the main constituents other than clinker shall be declared by designation of the cement (for examples, see Clause 8).

Extracted from EN 197-1

SABS Auto-Control & Conformity Criteria

- The conformity criteria is determined in accordance with SANS 50197-2, and it is designed to keep the auto-control results within a small range (amongst other things) in terms of variance between individual results over a given period, and this can be achieved by maintaining a low SD (Standard Deviation).

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- The main challenge (as mentioned earlier) is variability caused by fluctuations in raw material performance and this can result in non-conforming auto-control results i.e. even if all the individual results meet the single limit requirements and the average results are well above the requirements of SANS 50197-1, the variability in results can cause the SD to be above the allowed limit.

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- This requires close monitoring of results as the criteria are stringent and do not allow for much margin of error or variability, which in turn adds cost.

- This makes it a never-ending balancing act because the biggest variations are found in Unclassified Fly Ash (UCFA), which is the most widely used cement extender in the in-land region due to its relatively low cost and wide availability.

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- This requires close monitoring of results as the criteria are stringent and do not allow for much margin of error or variability, which in turn adds cost.
- This makes it a never-ending balancing act because the biggest variations are found in Unclassified Fly Ash (UCFA), which is the most widely used cement extender in the in-land region due to its relatively low cost and wide availability.
- There is much-needed improvement in the consistency of the performance of UCFA from different sources, which would go a long way in assisting us and the industry to maintain consistency in our own product range performance and manage the cost thereof.

Correlation of Results

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Fineness – Wet screening (45µm)

- The biggest variations have been found in fineness results of UCFA, with some occasionally failing to meet the requirements of SANS 50450-1
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- Finer FA enhances pozzolanic reaction, leading to stronger, more durable cement and concrete
- Increasing the fineness of fly ash marginally influences the flow of the blended cement pastes. The blended cement paste containing finer grade fly ash (CFA) generally generate higher compressive strength than the coarser grade fly ash (UCFA) but this is majorly dependant on a few factors. *(let's break it down)*

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Does finer always mean stronger?

- The surprising truth about FA particle size – a common assumption in cement chemistry is that finer particles always enhance strength due to increased reactivity, but recent research challenges this idea in that not all fine FA particles contribute equally to strength gain and that some coarser fly ash samples outperformed finer ones in long-term strength

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- Bound water analysis indicates hydration continues at different rates across size fractions.
- Sieve retention studies reveal that fly ash with balanced size distribution delivers better structural integrity than that of ultra-fine only systems.
- Therefore, a balanced mix of sizes ensures long-term durability and workability, and optimized grading improves both reactivity and packing density – a game changer for high performance concrete.

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The relationship between Particle size and strength

- Ultra fine ash (10 µm) – high surface area = fast reaction, but excessive fines can cause high water demand issues, risk of agglomeration (reduced dispersion and increased clumping)
- Fine fly ash (10 -45µm) – ideal balance of reactivity and packing efficiency, promoting optimal strength
- Coarse fly ash (≥45µm) – can reduce early strength but may enhance long-term performance by improving particle packing

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Potential Negative Effects of high LOI on UCFA:

- Loss on ignition refers to the loss in mass in a sample heated to up to a maximum of 1000 ◦C
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- **Slower Strength Gain:**
  Early strength gain might be reduced when using UCFA because it contains coarser particles.
- **Increased Dry Shrinkage:**
  Coarser FAs with high carbon content (high LOI) may increase dry shrinkage.
- **Efflorescence:**
  Fly ash concrete can be prone to efflorescence (salt deposits on the surface).
- **Seasonal Limitations:**
  Fly ash concrete may have seasonal limitations due to its slower strength gain.
  As the temperature drops, the rate of hydration drops, which in turn leads to decreased strength gain and increase setting times.

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Workability vs Strength: Finding the right balance

- **Can you have both workability and high strength?**
  Concrete mix design is a balancing act, increasing strength often means reduced workability- but making the right adjustments you can get both.
- **How Fly ash affects workability & Strength;**
  Fine Fly ash (≤ 45µm) High LOI fly ash absorbs water, making the mix sticky or dry.

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Research insights:

- Understanding Pozzolanic reactions – The chemistry of Strength
    - ❑ What makes Fly ash react & strengthen concrete
        - ❑ Fly Ash (SiO_2, Al_2O_3) + Calcium Hydrate(CH) + Water – C-S-H (Strength phase)
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INKOMU/SIYABONGA/THANK YOU/DANKIE/REALEBOGA!!!