Portland Limestone Cement at GU-Equivalent performance… How does it work?

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2. Objective of the study
3. Methodology and results
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Portland Limestone Cement (PLC)

- Lafarge will introduce PLC in Canada at GU-equivalent performance;
- Necessary step towards the reduction of the industry's CO_2 footprint;
- Seamless transition to PLC for our customer because of the equivalent performance;
- There are significant manufacturing implications to the equivalent performance: Blaine increase in the range of 10 m^2/kg for every additional percent of Limestone;
- PLC is not "just" dilution!

Portland Limestone Cement (PLC)

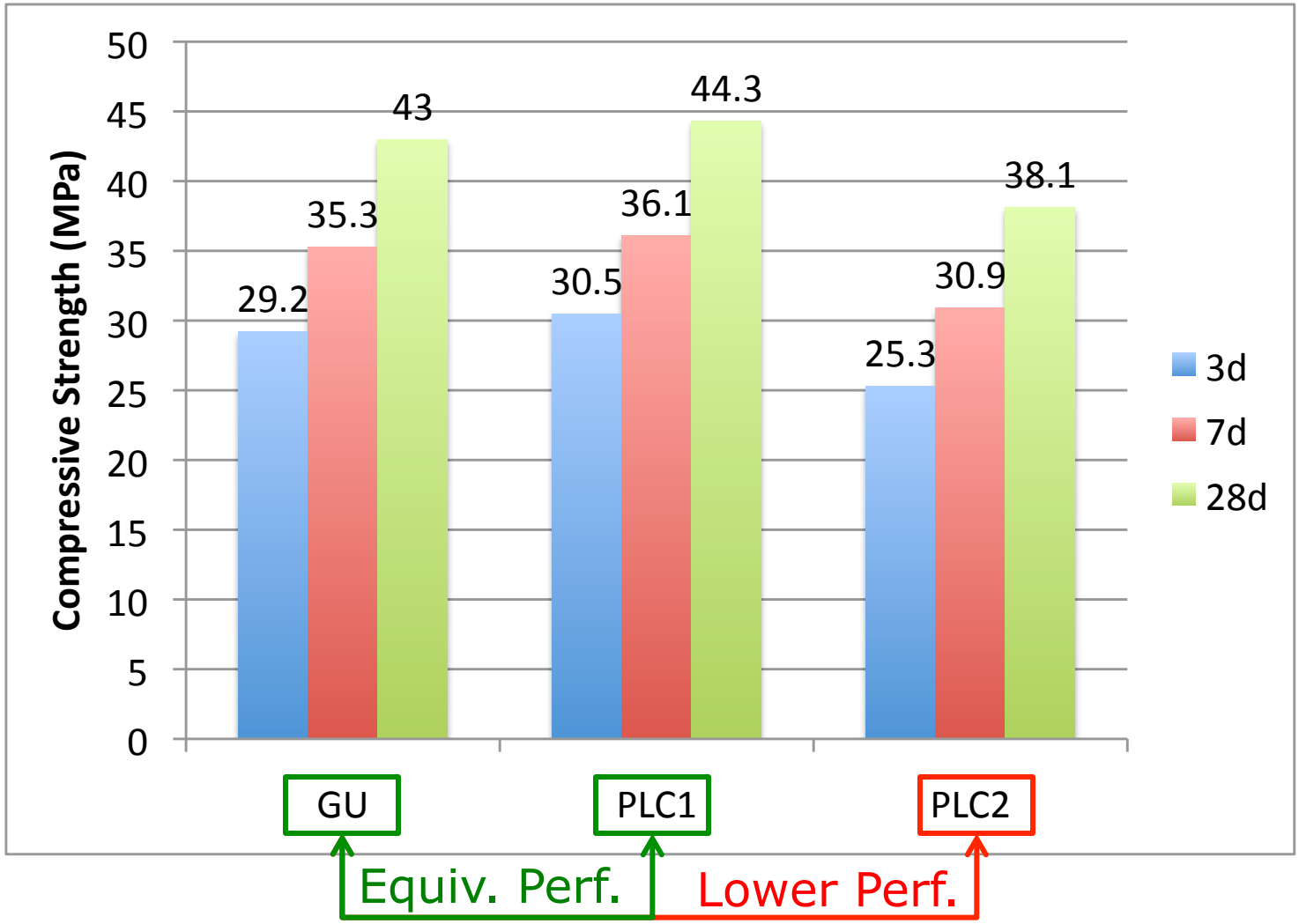
- Lafarge has performed several industrial trials to demonstrate the feasibility of the GU-equivalent performance concept;
- One of these trials was done in a plant equipped with 2 different milling circuits. One trial was successful and the other was not.
- We used these trials to try to understand better the underlying reasons of the equivalent performance.

The industrial trials

- Target:
  - Limestone: 14% (eq. 12% calcite)
  - Blaine: 490 m^2/kg
- Obtained:

	Control	Line 1	Line 2	Target
Designation	GU	PLC1	PLC2	
% Limestone	3.6%	13.5%	16.9%	14%
% Calcite	3.2%	11.7%	14.6%	12%
Blaine (m^2/kg)	395	474	475	490
Blaine increase		+8 $m^2/kg/\%L$	+6 $m^2/kg/\%L$	+9 $m^2/kg/\%L$

Performance Results



Potential Benefits of Limestone addition

- **Intrinsic** Benefits of inter-ground limestone
  - **3** **Packing effect** leading to the reduction of the water demand;
  - **3** Increase of the **volume of cement paste** also leading to the reduction of the water demand;
  - **2** **Heterogeneous Nucleation** providing faster kinetics of hydration;
  - **3** **Carbo-aluminates** formation providing additional hydrates
- **Additional** Benefits of our approach
  - **1** Clinker is ground finer to compensate its dilution

What we believe is the "strength" of each of these benefits

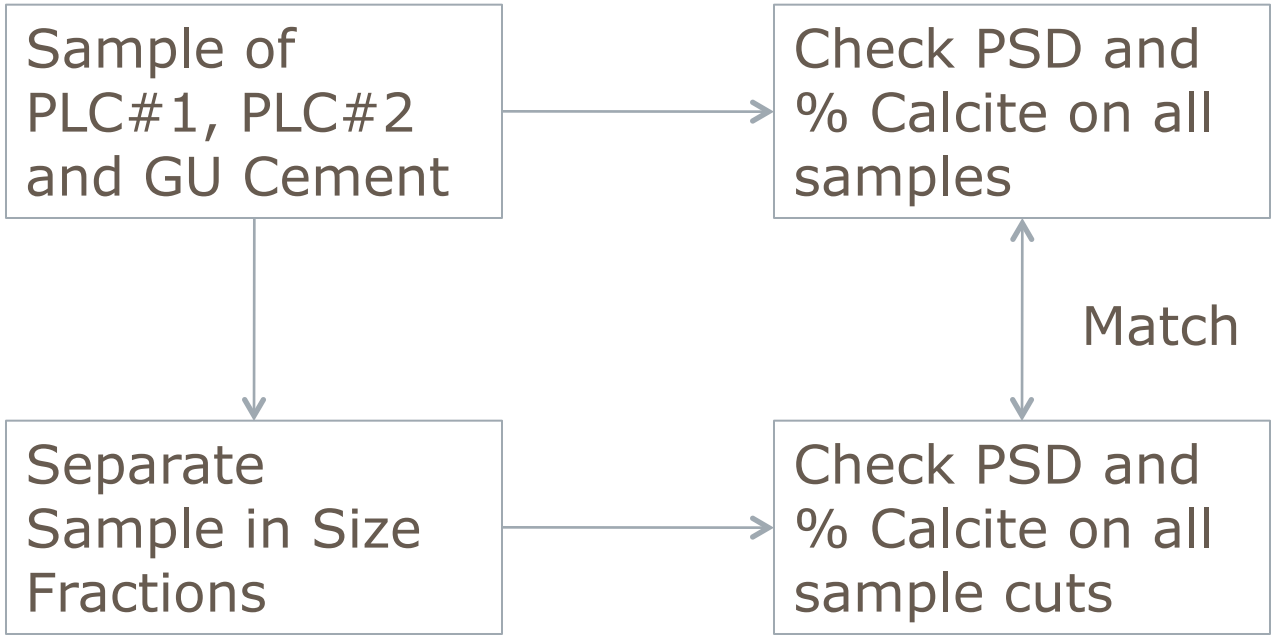
Purpose of the study

- Show that when Blaine is increased in the range of +10 m^2/kg per percent additional limestone, **clinker is ground finer than in GU**.

- Show that, among the other benefits, the fact of clinker being ground finer **accelerates the kinetics in such a way that it is the main lever to achieve equivalent performance.**

The Methodology

1. Size Fractions



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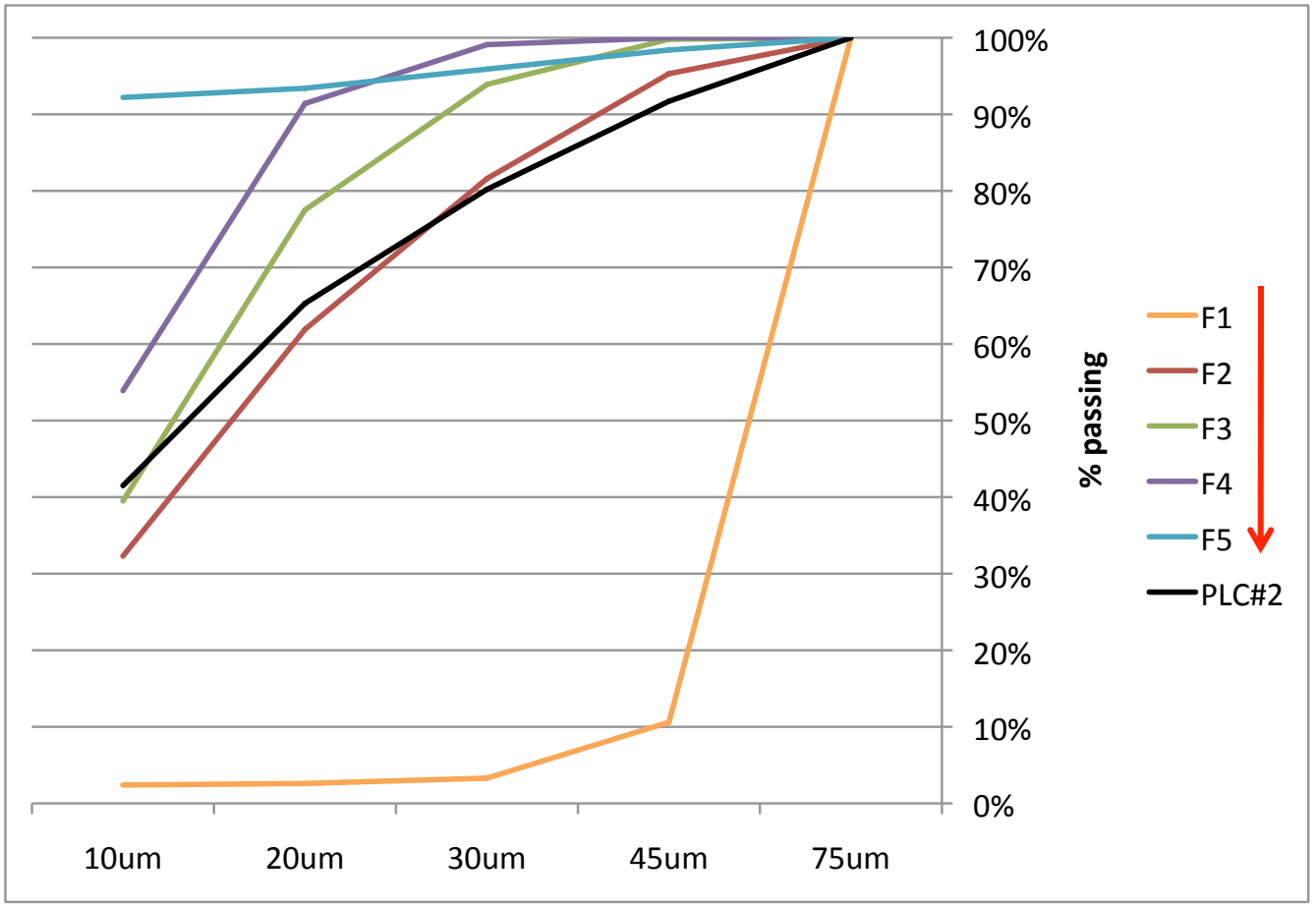

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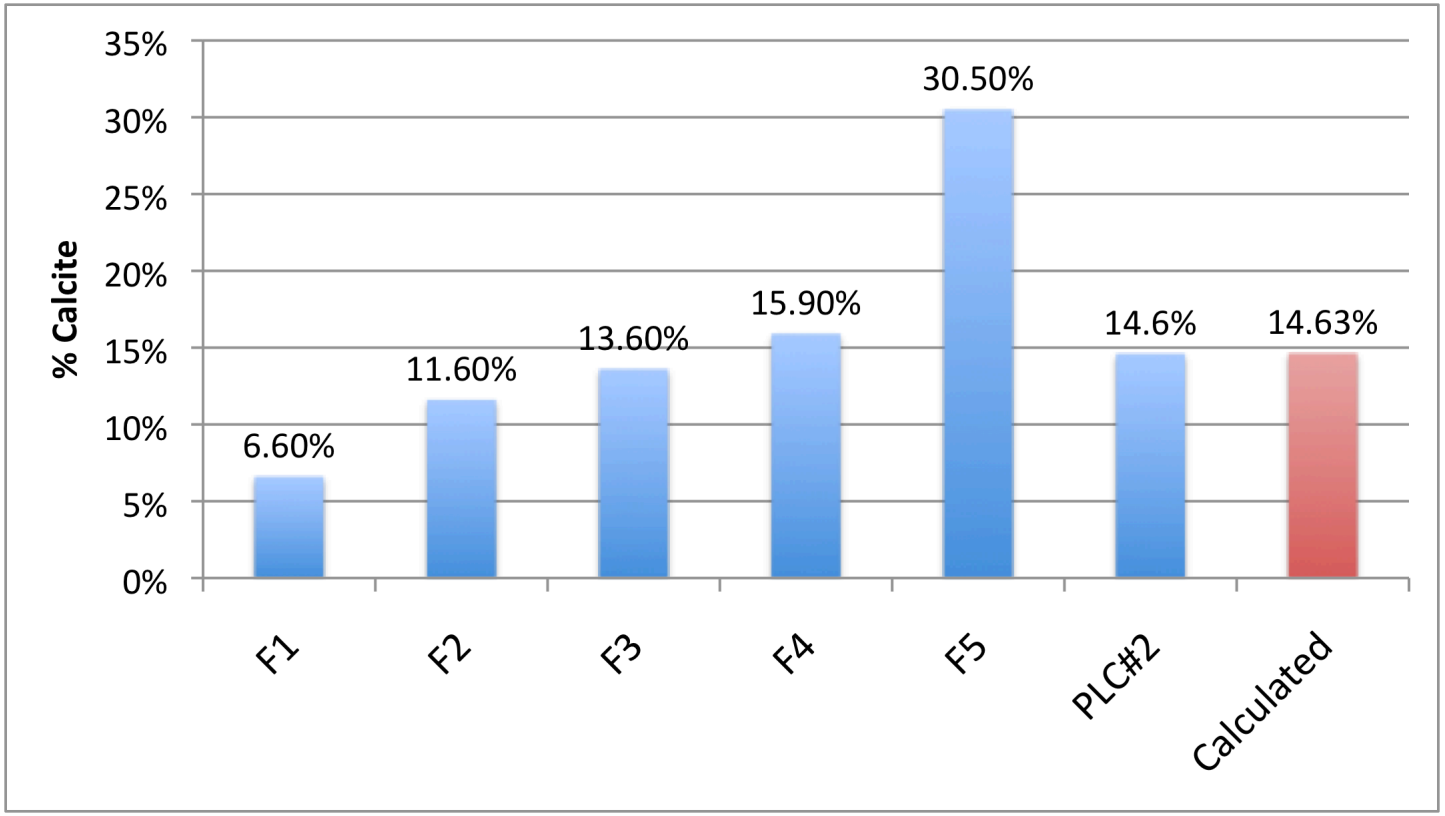
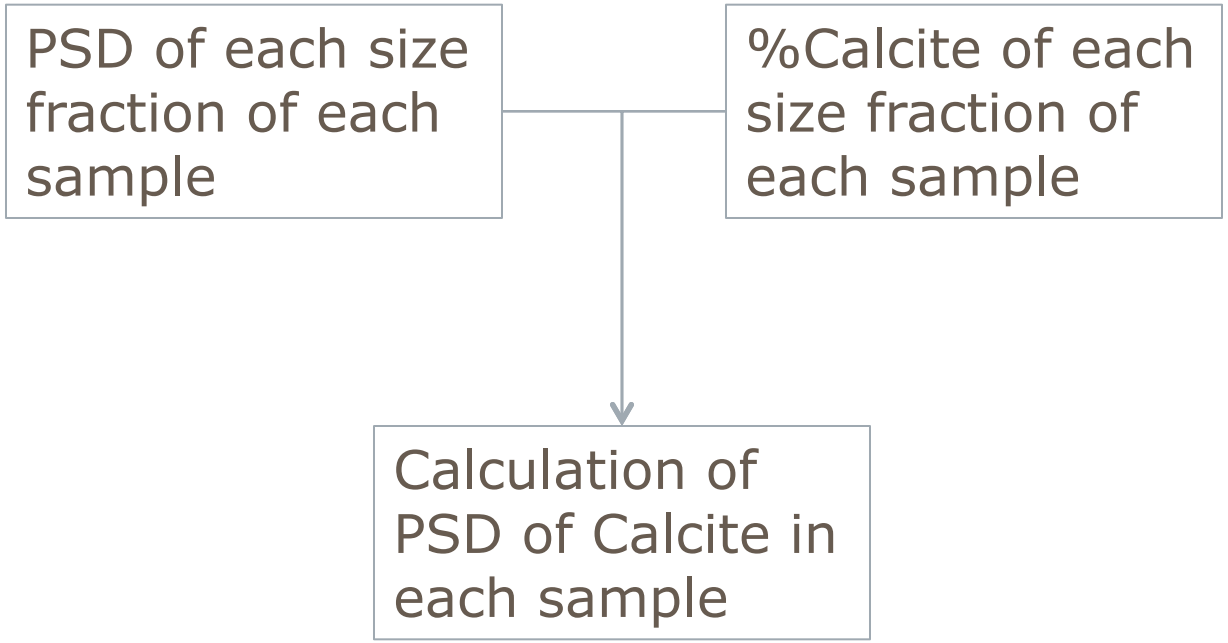


1. Non uniform LS content: The finer the fraction, the higher the limestone;
2. Good match between measured and calculated %LS

The Methodology

2. Determination of LS fineness



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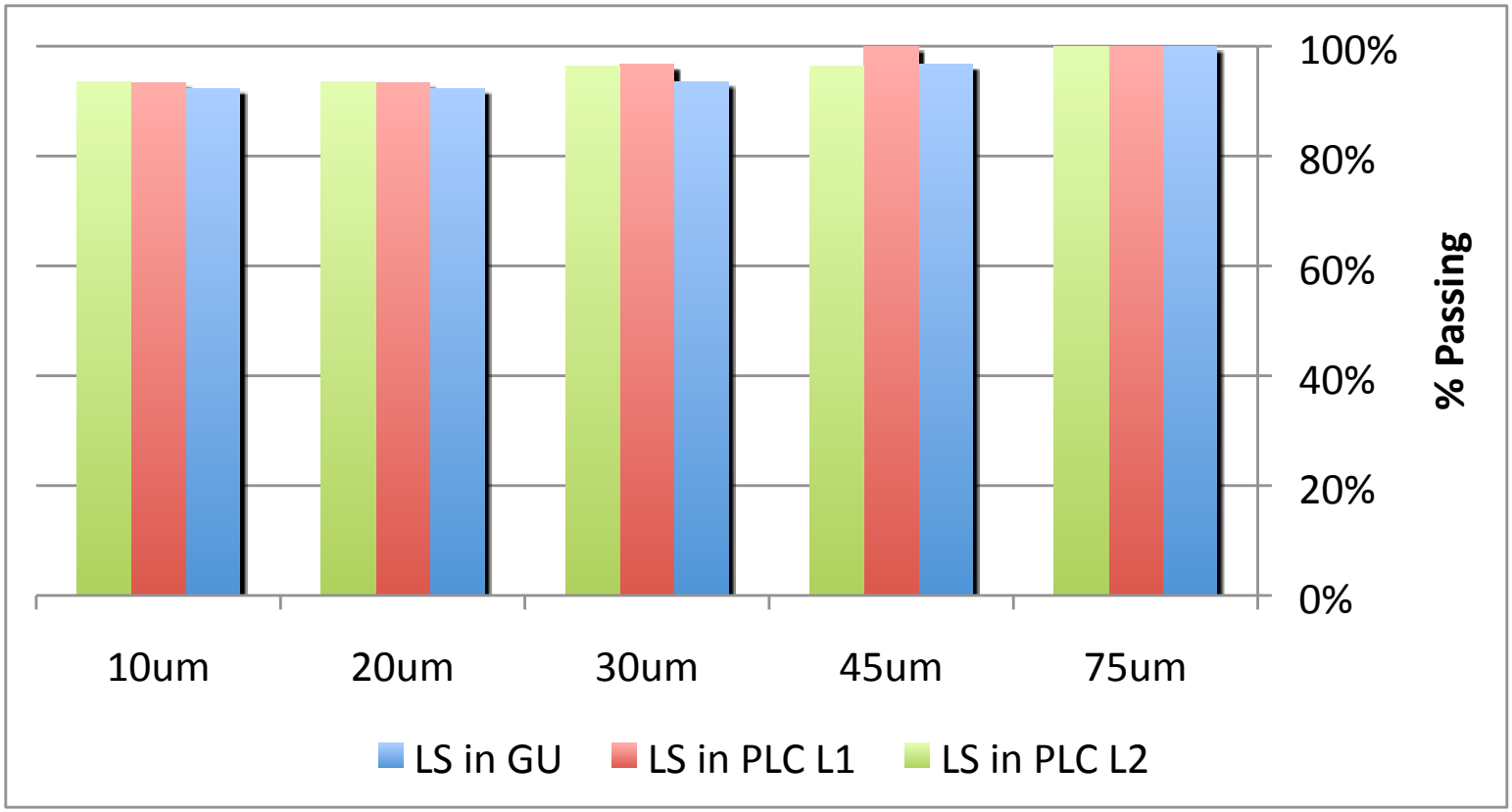
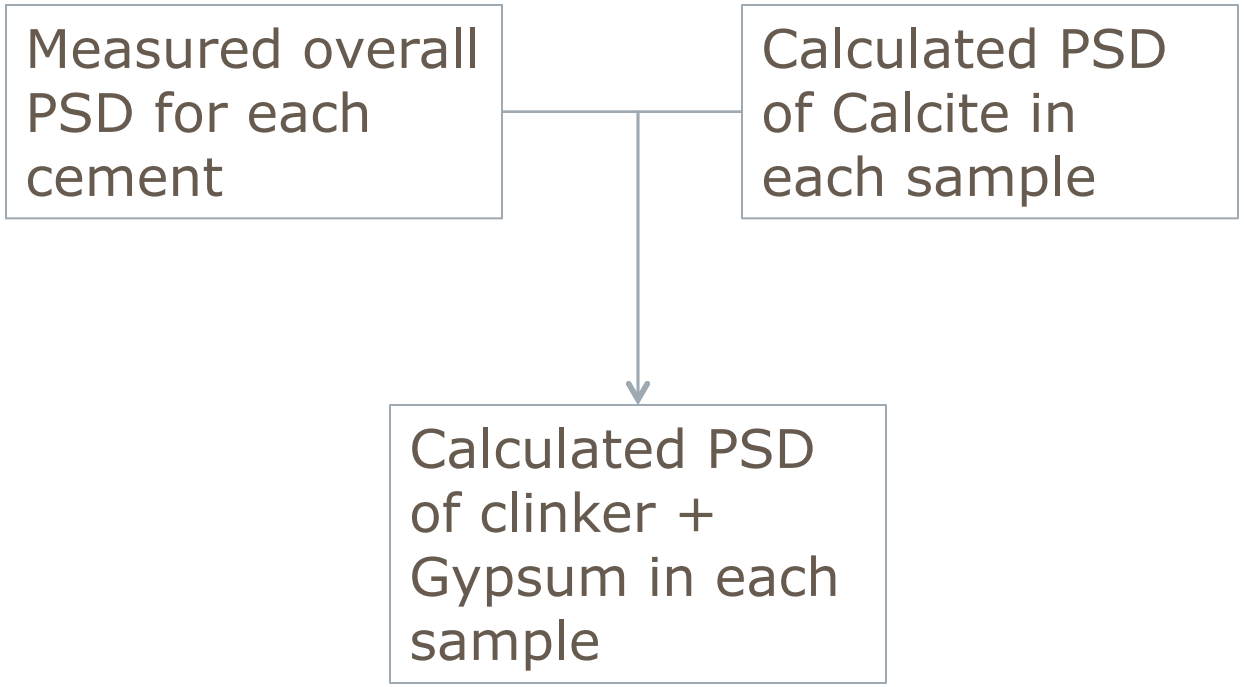


1. Overall, limestone is very fine in all 3 cements, 90%+ being finer than 10um.

The Methodology

3. Determination of Clinker fineness



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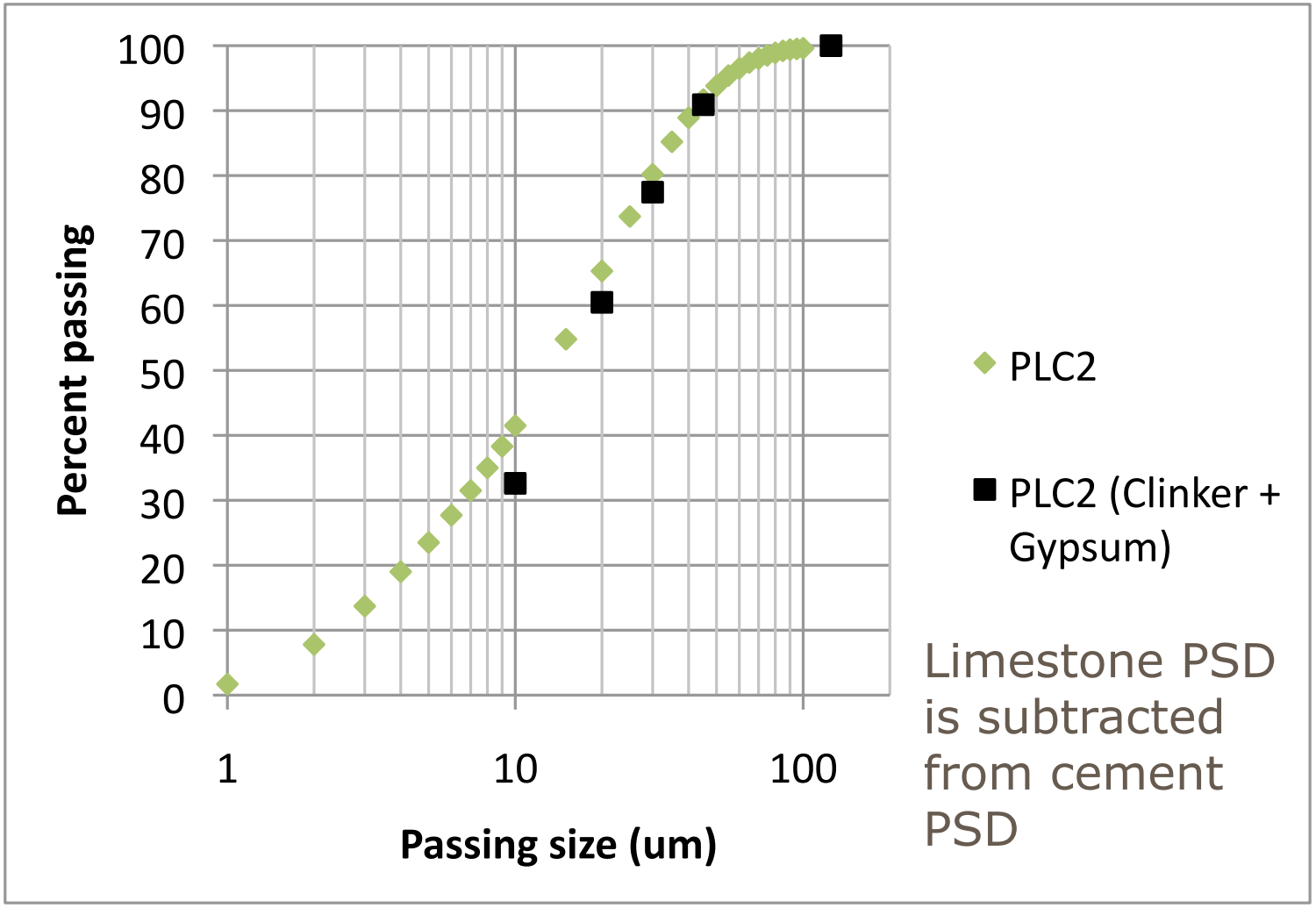

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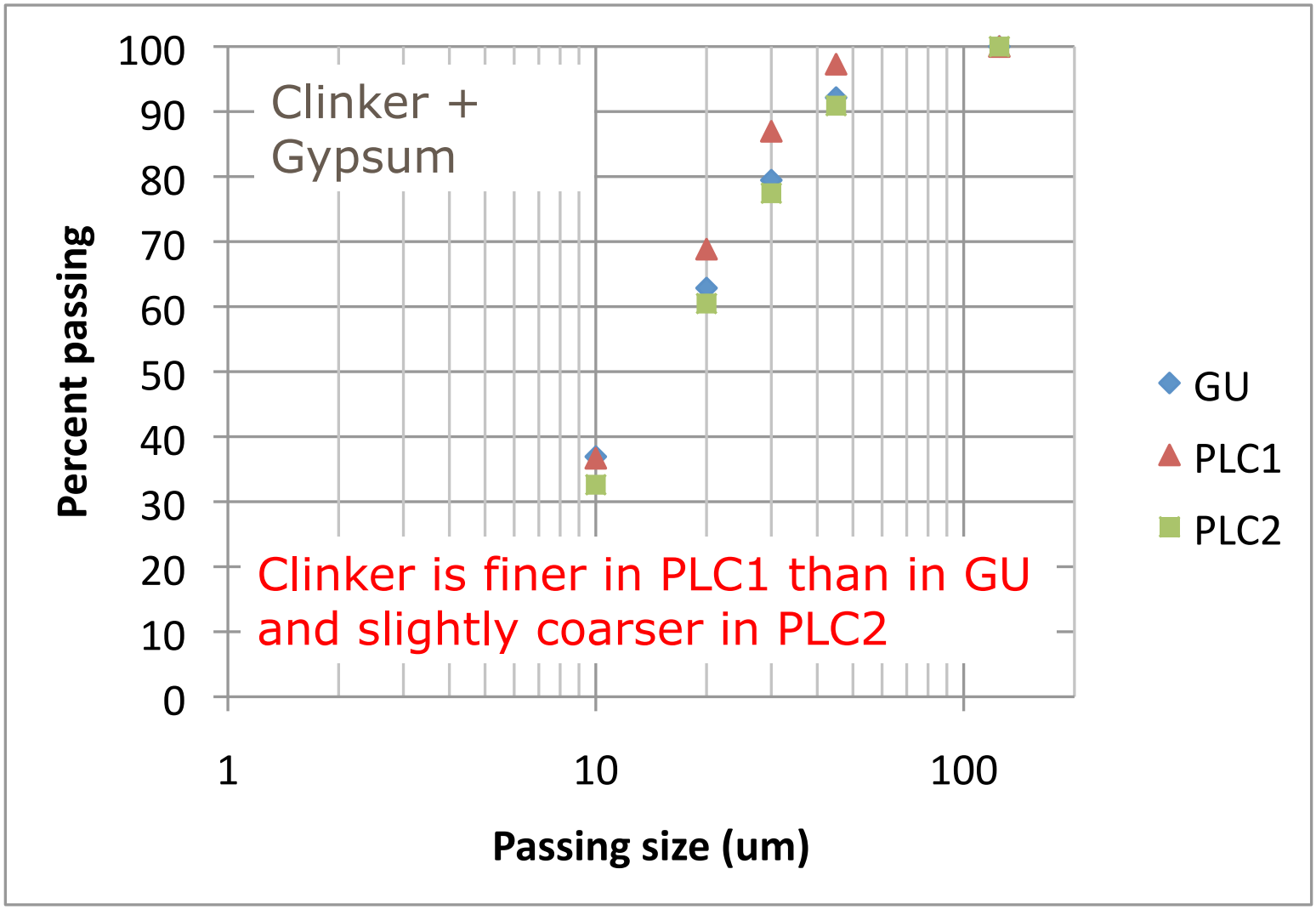
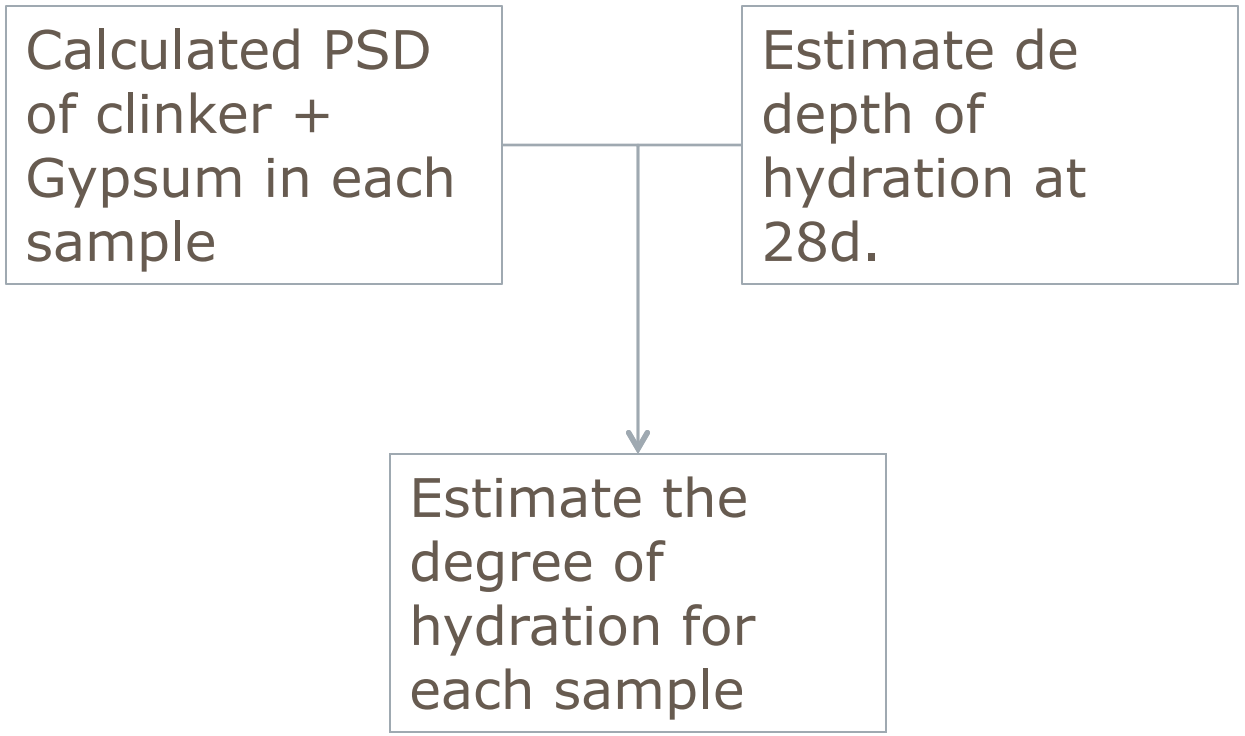


The Methodology

4. Simulation of impact on degree of hydration



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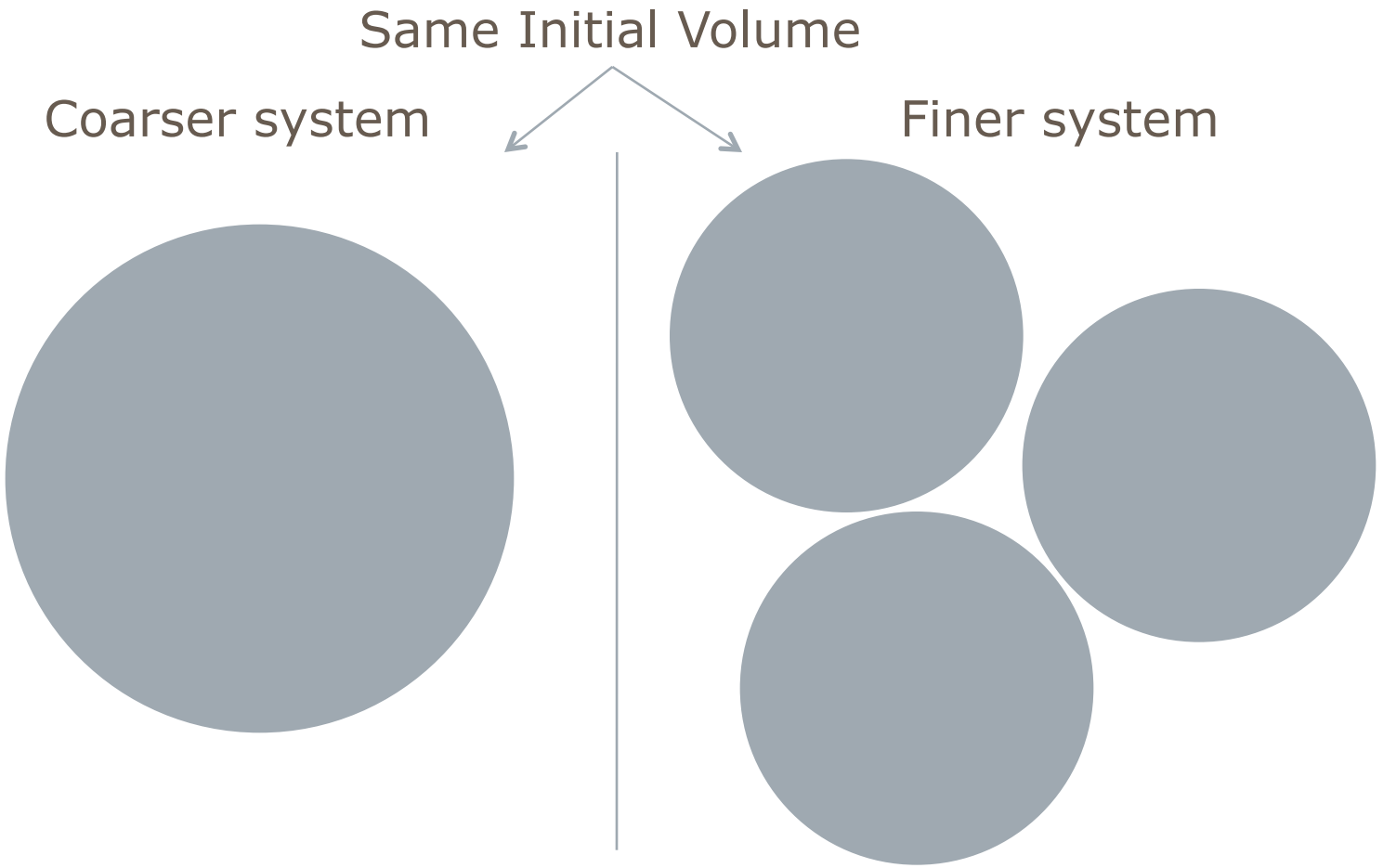

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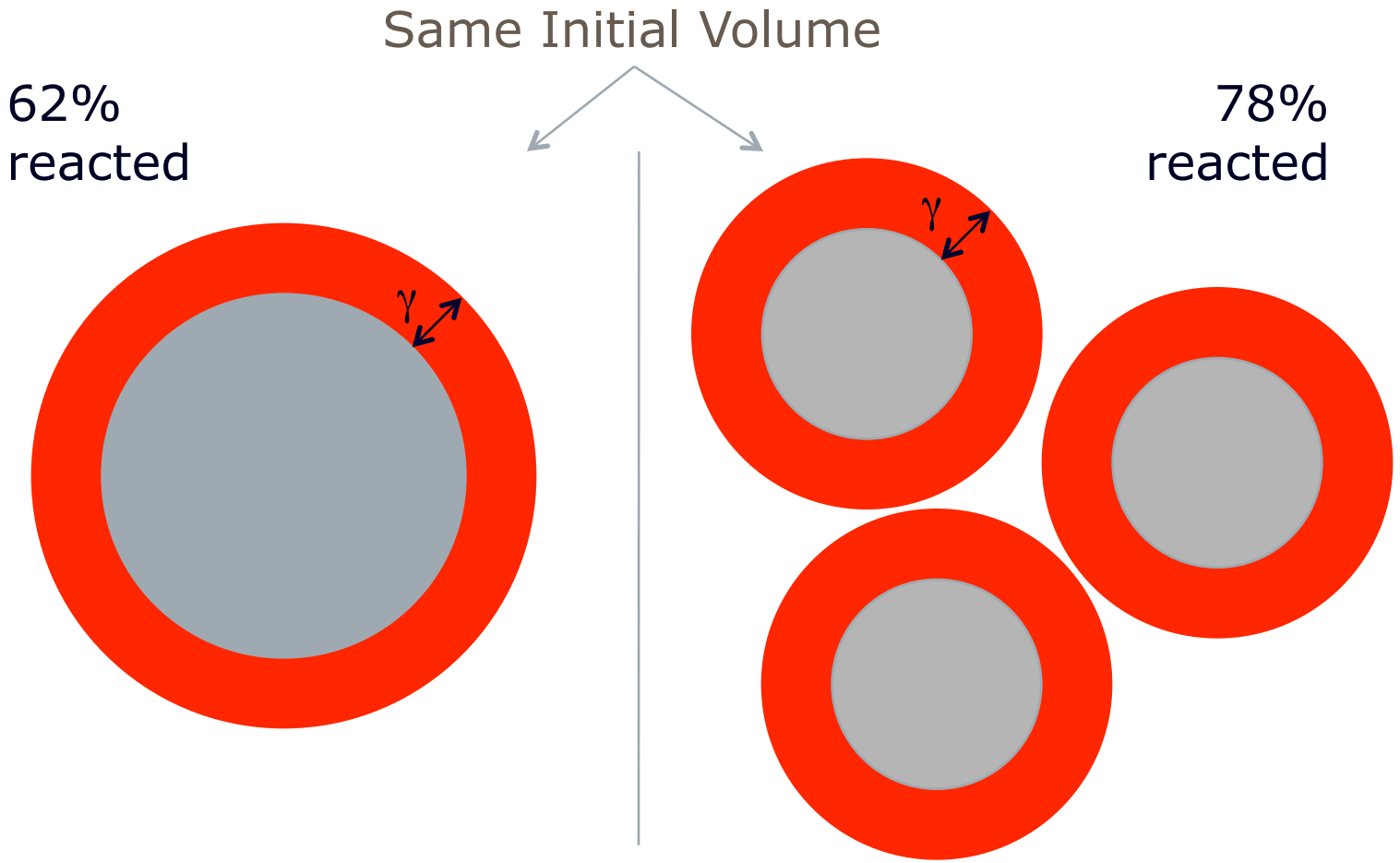

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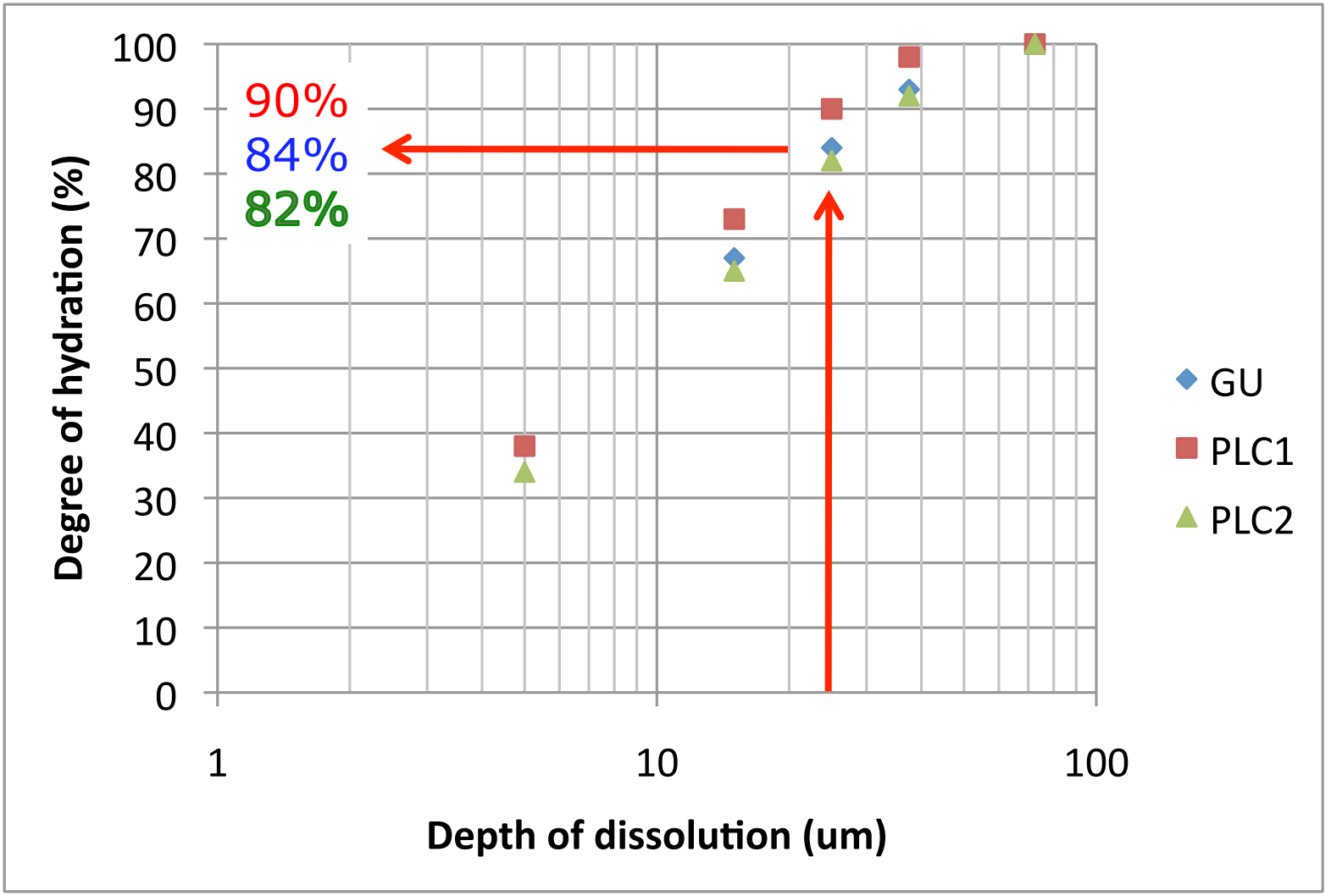

4. Simulation of impact on degree of hydration

	GU	PLC#1	PLC#2
% Limest.	3.6%	13.5%	16.9%
% Gypsum	5%	4.5%	4.5%
% Clinker	91.4%	82%	78.6%
α at 25um dissolved	84%		
Cement reacted	**77%**		

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If dilution only		**69%**	**66%**

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% Clinker	91.4%	82%	78.6%
α at 25um dissolved	84%	90%	82%
Cement reacted	**77%**	**74%**	**64%**
If dilution only		**69%**	**66%**

+5% (>60% of the gap)

Gap: 8%

Conclusion:
Purpose of the study

- ✓ Show that when Blaine is increased in the range of +10 m^2/kg per percent additional limestone, **clinker is ground finer than in GU**.

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