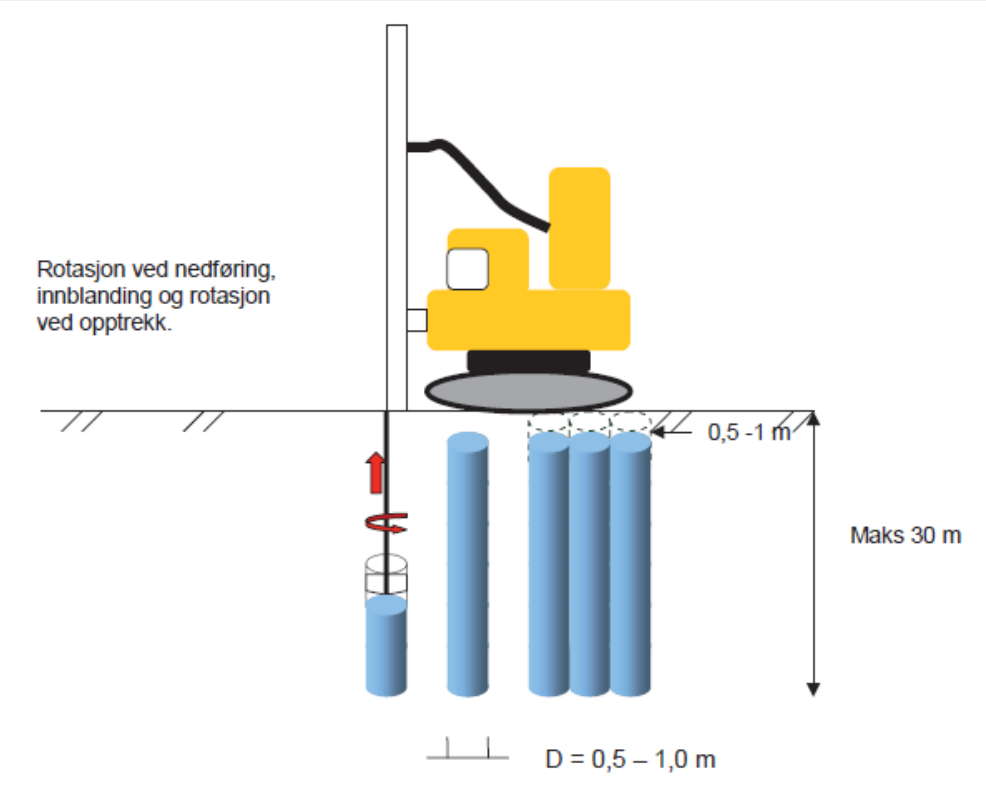
SUSI
SUstainable Soil Improvement

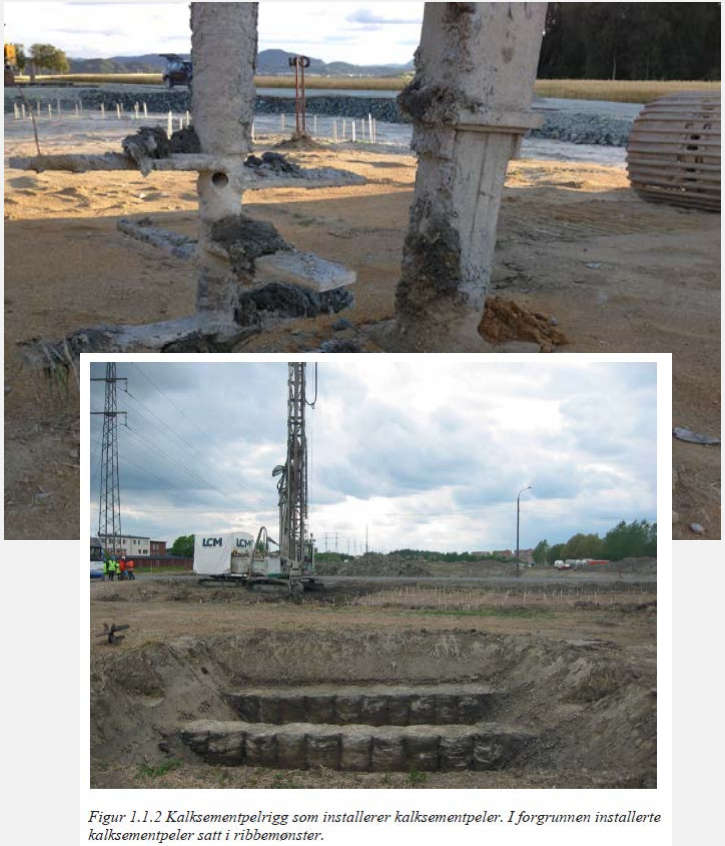
Avslutningsseminar 2020-12-11

Priscilla Paniagua
Senior rådgiver, NGI Trondheim

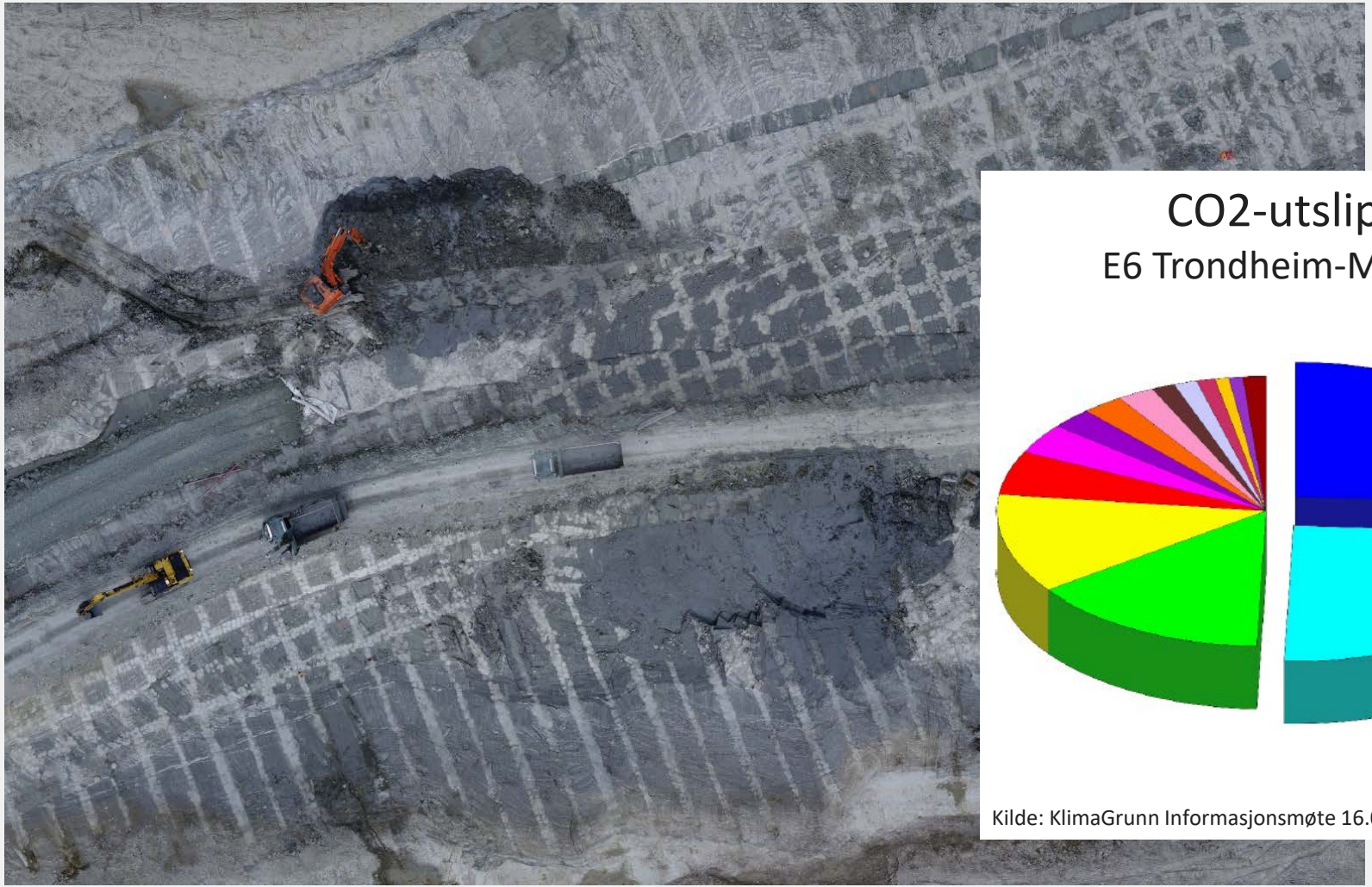
Grunnforsterkning med kalk og sement



Kilde: KS-veileder NGF 2012



Figur 1.1.2 Kalksementpelrigg som installerer kalksementpeler. I forgrunnen installerte kalksementpeler satt i ribbemønster.



CO2-utslipp

E6 Trondheim-Melhus

Kilde: KlimaGrunn Informasjonsmøte 16.03.2020

SUSI mål

Goal: Find the most sustainable and economical amount and type of binder to improve strength and deformation properties of sensitive clays

NGI MELHUS KOMMUNE FRANZEFOSS MINERALS JLE GRUNNFORSTERKNING AS

REGIONALE FORSKNINGSFOND TRØNDELAG

SUSI mål

Goal: Find the most sustainable and economical amount and type of binder to improve strength and deformation properties of sensitive clays

WP1: Laboratory testing to find the minimum amount of binder necessary to improve strength and deformation properties of sensitive clays	WP2: Sustainability and cost-benefit evaluation for the optimum binder types and amounts used in WP1	WP3: Recommendations for the practical application of the results obtained and relevance for the community by evaluating the outcomes in a real case in Lundamo, Melhus

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SUSI – WP1: Lab resultater for de ulike bindemidlene

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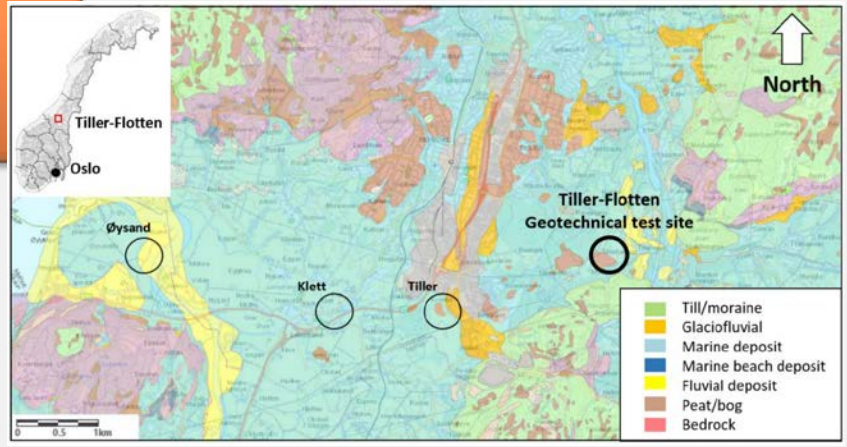
Kalk: Stabila B100, B80, B60, LKD

+

Standard sement FA (CEM II/B-M)

Tiller-Flotten kvikkleire Trondheim



Kilde: L'Heureux JS, Lindgård A, Emdal A (2019) The Tiller-Flotten research site: Geotechnical characterization of a very sensitive clay deposit. AIMS Geosciences. 2019, 5 (4), 831-867

Overview of constituents in the different types of lime

Product	CaO-active [%]
LKD (Lime Kiln Dust)	<30
Stabila B60 (CL 70-Q)	75 ± 5
Stabila B80 (CL 80-Q)	85 ± 5
Stabila B100 (CL 90-Q)	95 ± 5

Lab program (tidligere forskning)

Binder content [kg/m³]	Number of UC tests per binder						
	LKD + cement 50/50	B60 + cement 50/50	B80 + cement 50/50	B100 + cement 50/50	LKD 100%	B100 100%	Cement 100%
10							
15							
30							
25							
30	x*	x*	x*	x*			
35							
40							
45							
50							
60	x*	x*	x*	x*	x*	x*	x*
90	x*	x*	x*	x*	x*		
110	x* & x**	-	x* & x**				

*(NGI 2019)
**Clay from Sognsveien 72. UC performed after 2 and 28 days. Curing temperature was 8°C.

Lab program - SUSI

Binder content [kg/m³]	Number of UC tests per binder, UC @ 28 days						
	LKD + cement 50/50	B60 + cement 50/50	B80 + cement 50/50	B100 + cement 50/50	B40 100%	B100 100%	Cement 100%
10		x	x	x			
15		x	x	x			
20		x	x	x			
25		x[1]	x[1]	x[1]			
30	x*	x*,[2]	x*,[2]	x*,[2]			
35	x						
40	x						
45	x						
50	x[1]						
60	x*,[2]	x*	x*	x*	x*	x*	x*
90	x*	x*	x*	x*	x*		
110	x* & 4**		x* & 4**				

*(NGI 2019)

**Clay from Sognsveien 72. UC performed after 2 and 28 days. Curing temperature was 8°C.

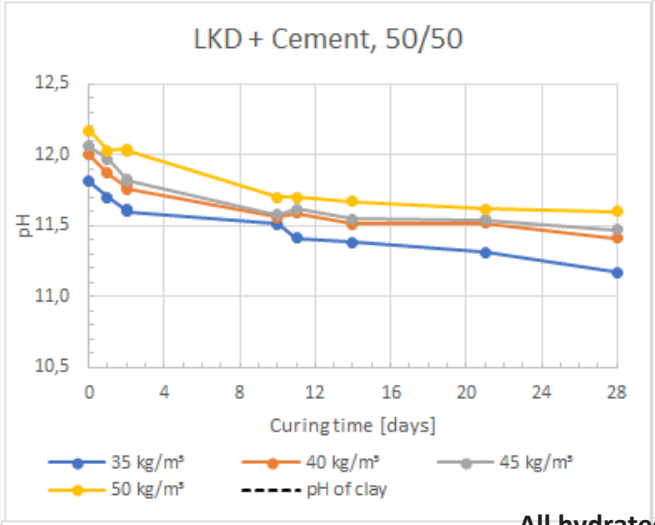
[1]One sample analysed by SEM

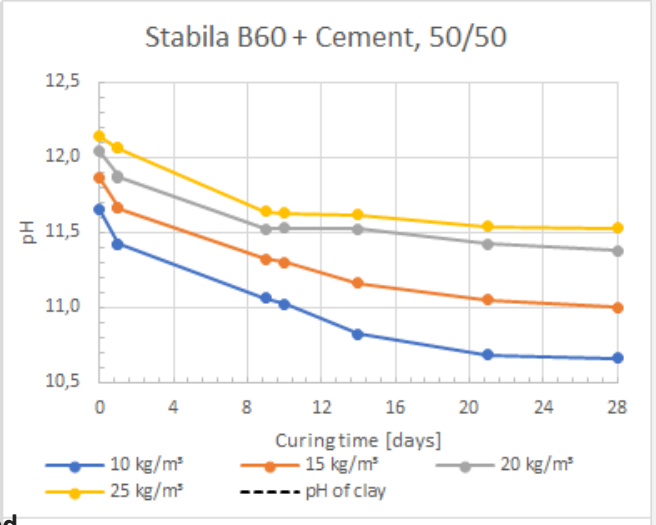
[2]One additional sample analysed by XRD and XRF

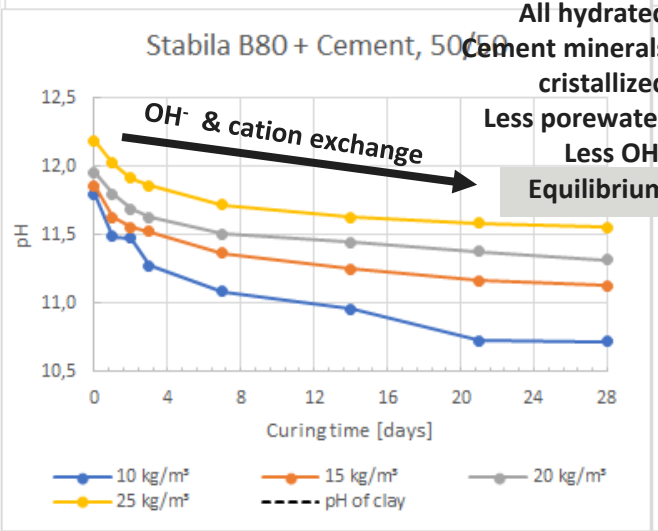
pH @ herdetid

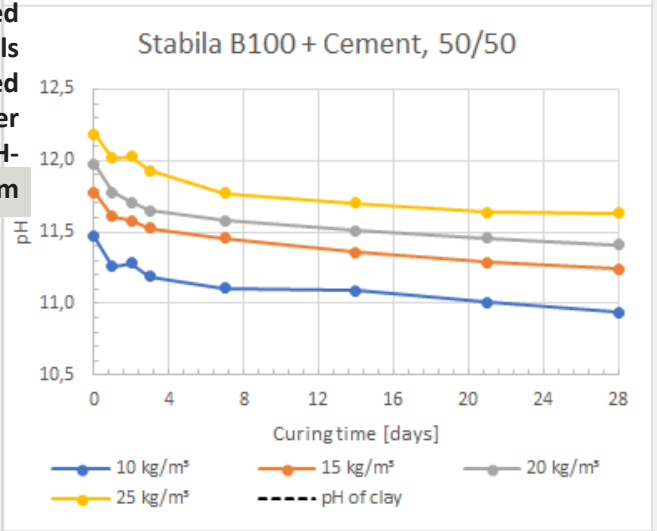
Atterberg limits & vanninnhold

pH





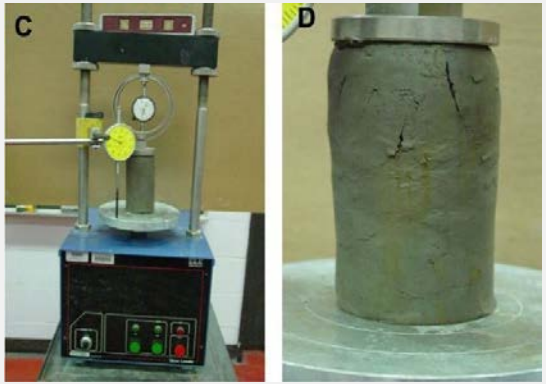


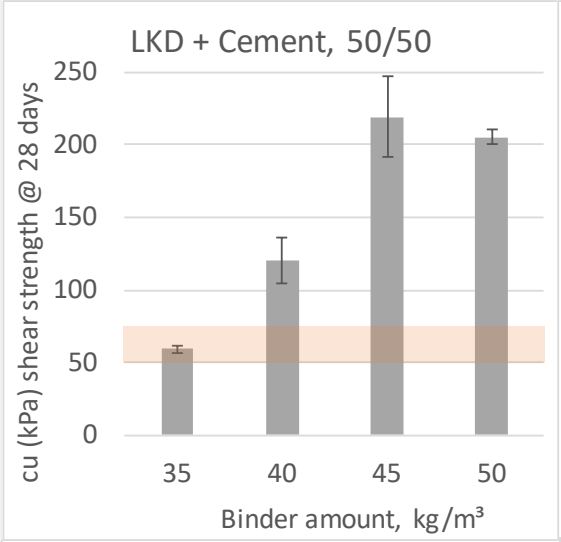


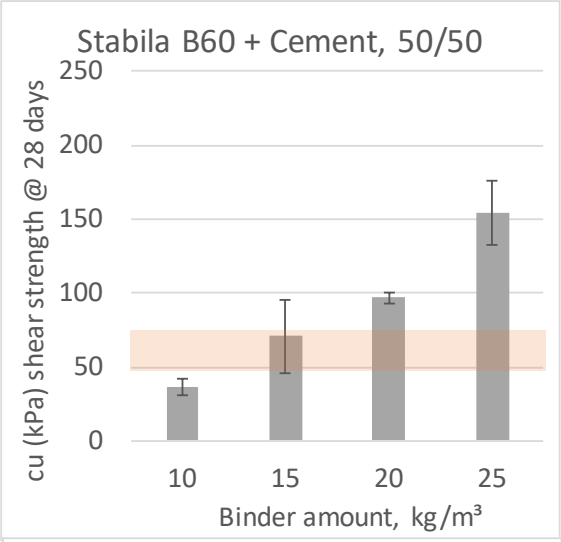
All hydrated Cement minerals cristallized
Less porewater
Less OH-
Equilibrium

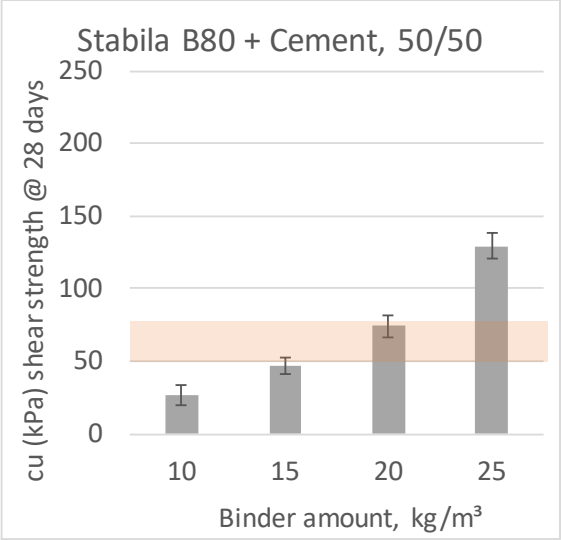
↑pH & T
↓w
OH^- in porewater

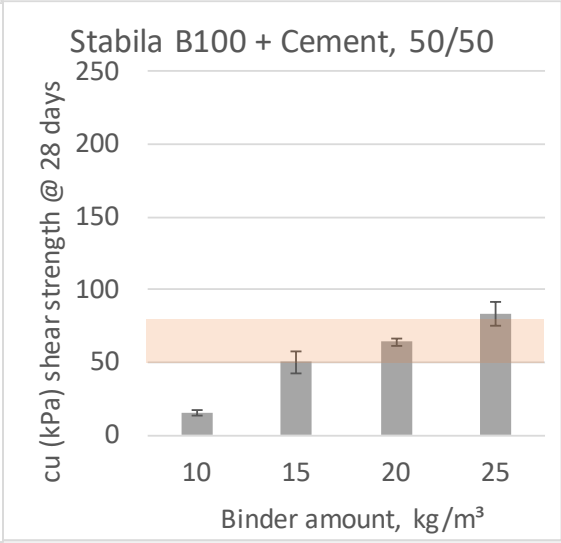
Styrke


C
D

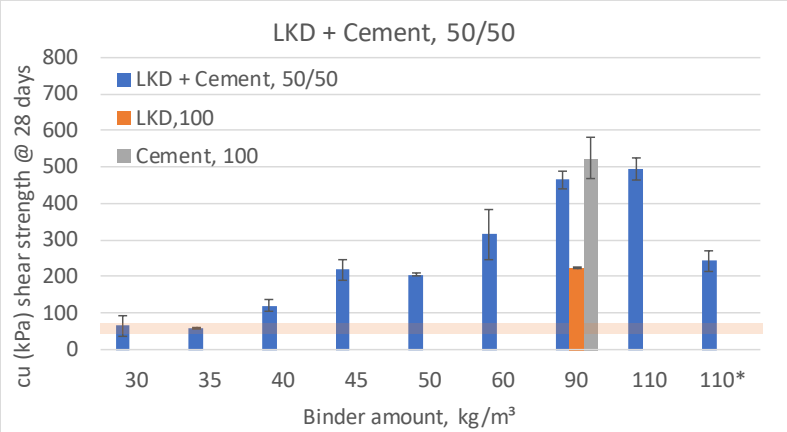

LKD + Cement, 50/50
cu (kPa) shear strength @ 28 days
250
200
150
100
50
0
35
40
45
50
Binder amount, kg/m³

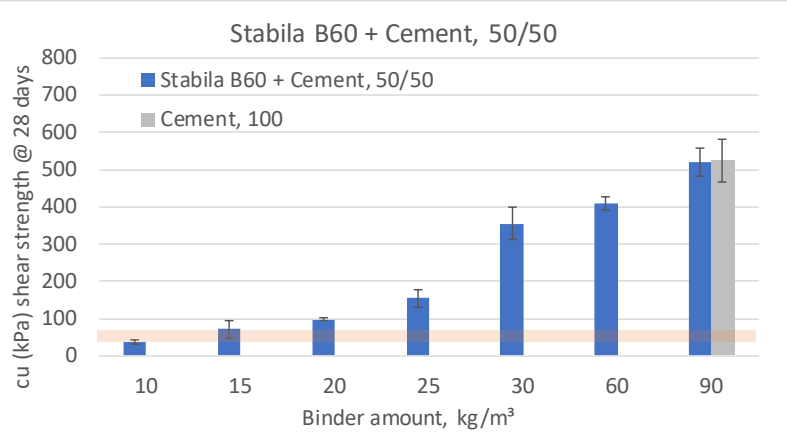

Stabila B60 + Cement, 50/50
cu (kPa) shear strength @ 28 days
250
200
150
100
50
0
10
15
20
25
Binder amount, kg/m³

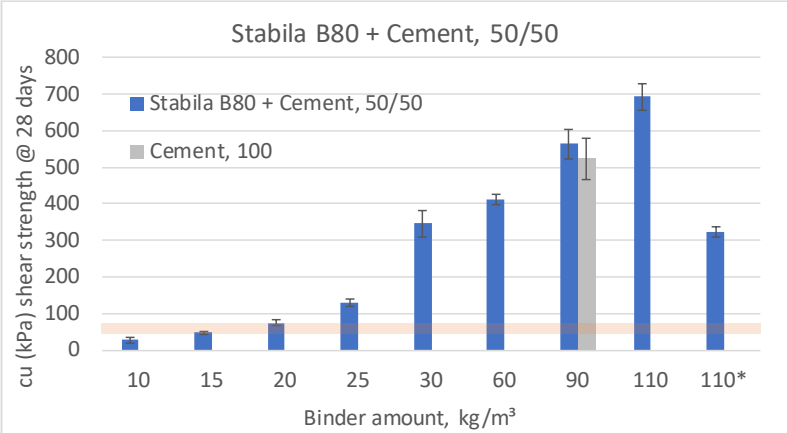

Stabila B80 + Cement, 50/50
cu (kPa) shear strength @ 28 days
250
200
150
100
50
0
10
15
20
25
Binder amount, kg/m³

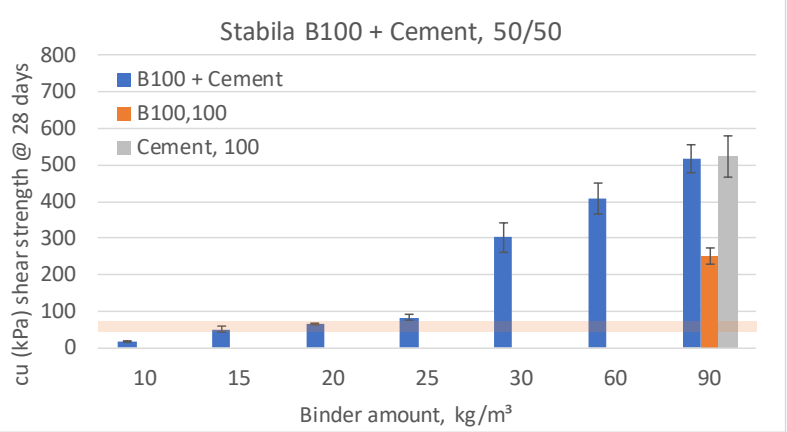

Stabila B100 + Cement, 50/50
cu (kPa) shear strength @ 28 days
250
200
150
100
50
0
10
15
20
25
Binder amount, kg/m³

SUSI + tidligere data



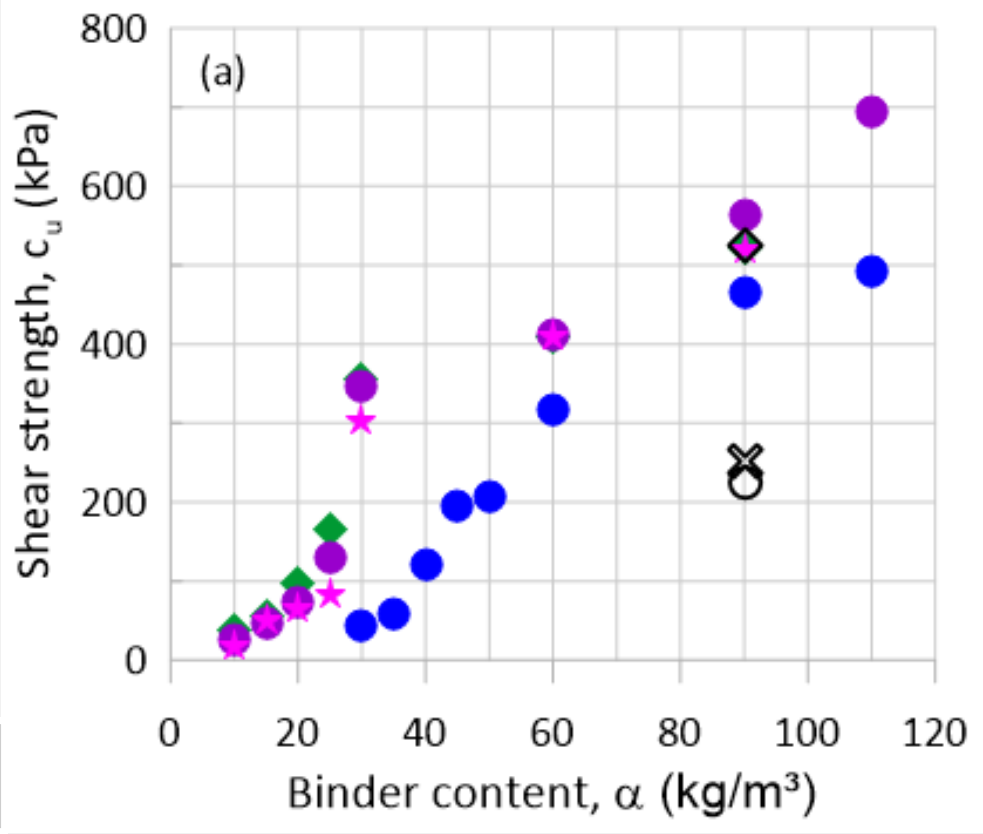






Optimum verdier

Binder type, 50/50	Binder content (kg/m³)	Reached shear strength at 28 days (kPa)
LKD + cement	60	300
Stabila B60 + cement	30	300
Stabila B80 + cement	30	300
Stabila B100 + cement	30	300



Conclusions

- Based on SUSI and previous results, the optimum amount of binder for increase in strength and stiffness is 60 kg/m^3 for low reactivity binders (LKD + cement) and 30 kg/m^3 for higher reactivity binders (B60 + cement, B80 + cement, B100 + cement).

- Measurements of water content, Atterberg limits (plasticity) and pH value tend to stabilize at similar values near the optimum amount of binder mention in the previous point.

- The optimum binder contents give a strength increase (in unconfined conditions) up to 300 kPa. These optimum values for binder content correspond also to the minimum number of CO_2-equivalents from binder production.

- There is a beneficial climate effect when using a binder with a low proportion of burnt lime (CaO) and a reduced binder content

NGI

#påsikkergrunn

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