

European Union  
European Regional Development Fund



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# Geomaterials project

- Geopolymer binder mix development for structural applications



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storaenso



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# KAMK University of Applied Sciences

- Appr. 2000 students
- Mechanical and Mining Engineering is one focus area
- Research and development supports education and industry within the region

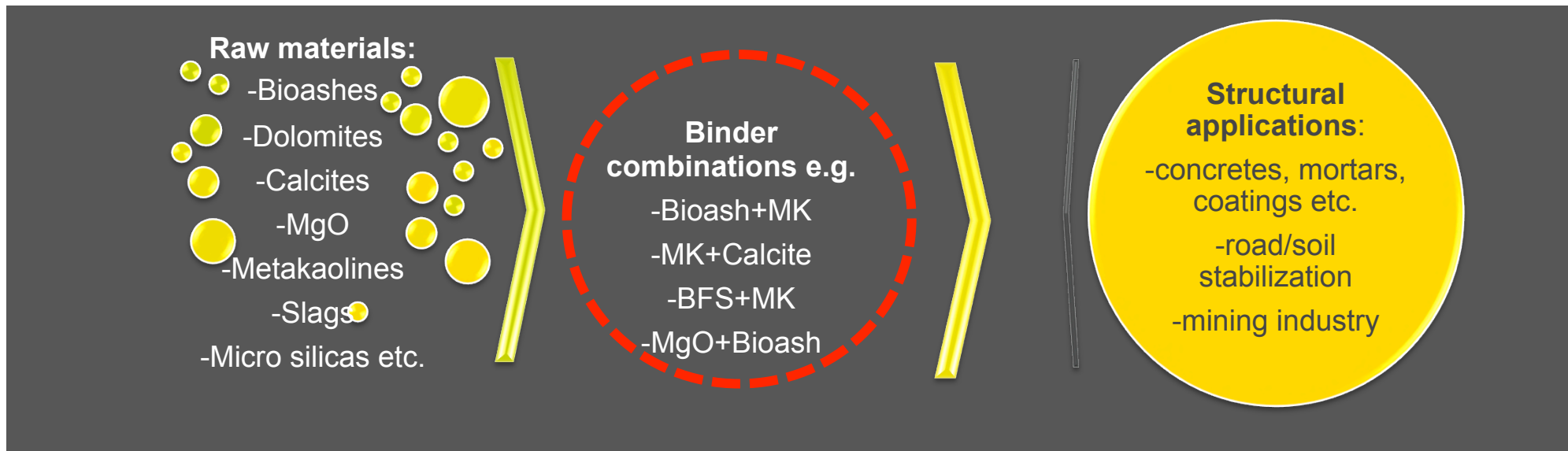


# R&D Focus of the project GeoMaterials

Research and processing of regional mineral resources and industrial by-products:

- develop new methods to improve utilization of industrial by-products
- research and develop new products based on geopolymer technology
  1. applications for building industry
  2. adsorbents for waste water treatment
  3. mixes for soil stabilization

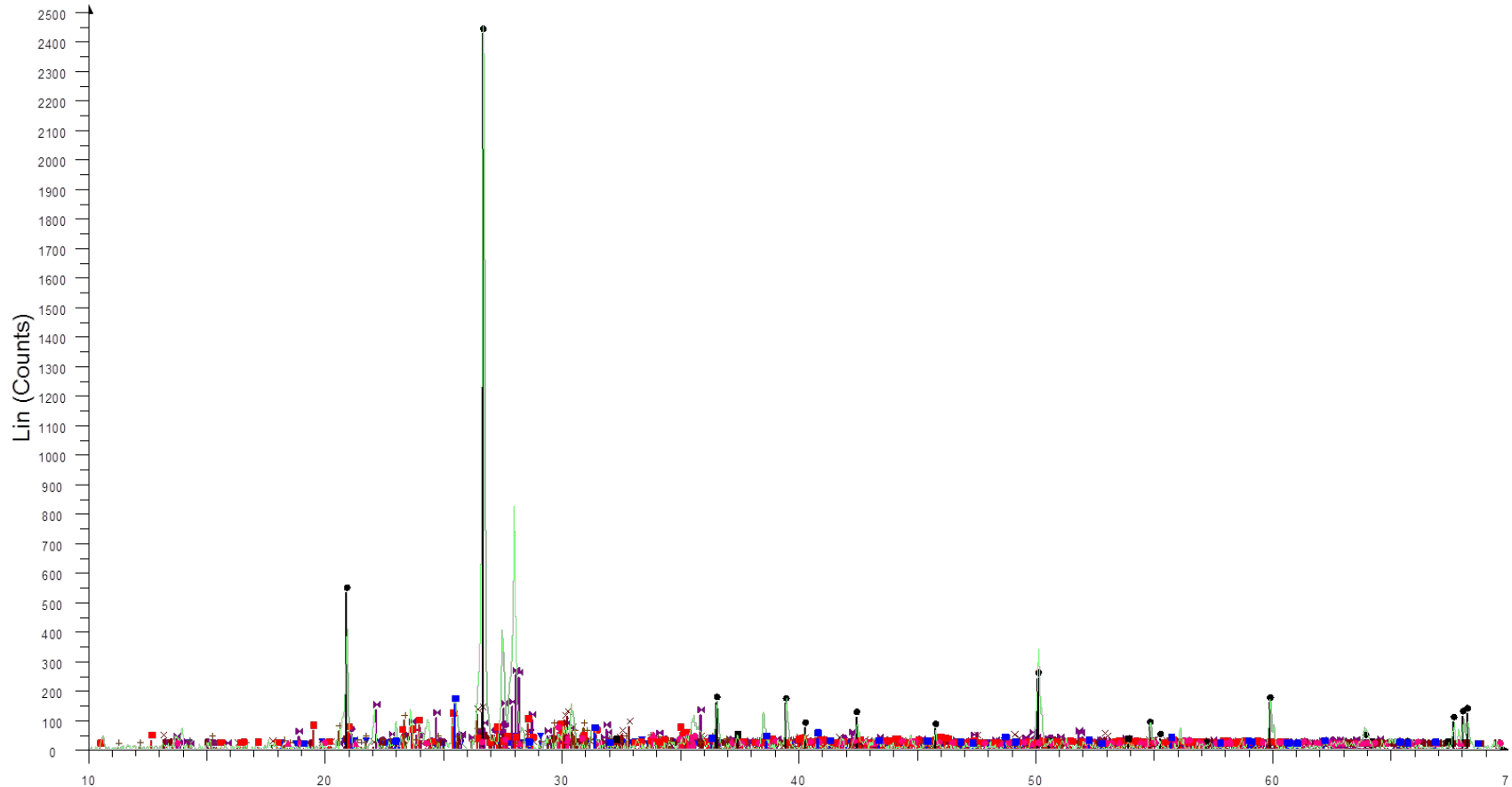
## Platform concept for geopolymer binder mix development for structural applications



# XRF: fly ashes

	Näyte	Na <sub>2</sub> O (%)	MgO (%)	Al <sub>2</sub> O <sub>3</sub> (%)	SiO <sub>2</sub> (%)	P <sub>2</sub> O <sub>5</sub> (%)	S (%)	K <sub>2</sub> O (%)	CaO (%)	TiO <sub>2</sub> (%)	FeO (%)	summa
BA1	LT Stora Enso 04_02_13	1,20	1,57	5,79	28,15	1,65	1,47	2,28	42,89	0,24	5,43	90,67
	LT Stora Enso 09_12_13	1,40	2,57	7,17	26,55	3,86	3,83	2,76	32,29	0,32	11,19	91,94
BA2	NT 11-12 x < 45 µm	3,03	2,24	12,66	58,76	1,03	0,16	3,99	7,29	0,67	8,31	98,14
	NT 12 x < 35 µm 21.3.-14	2,28	1,99	12,94	51,94	1,97	1,67	3,71	10,27	0,94	8,88	96,59
	NT 12 x > 35 µm 21.3.-14	3,12	1,75	14,78	62,30	1,03	0,39	3,27	7,08	0,65	4,66	99,03
	NT 12 original 21.3.-14	2,68	1,85	13,51	57,31	1,50	0,95	3,47	8,37	0,78	6,41	96,83
	NT (11)_12 35 < x < 45 µm 26.3.	3,05	1,67	12,65	65,15	1,04	0,32	3,12	6,93	0,63	4,47	99,03
	NT 12 Kavo 20.1.	2,50	2,29	13,11	51,87	1,63	1,77	3,01	9,71	0,92	8,44	95,25
	NT 12 2013	1,88	2,66	10,59	44,56	2,09	2,23	3,14	13,46	0,57	13,92	95,10
CFA	Kivihiilituhka Hanasaari 27.12.-13	0,07	1,49	20,03	49,00	0,72	0,21	2,79	5,07	1,01	5,80	86,19
	Kivihiilituhka Salmiasaari 26.12.-13	0,55	2,23	23,19	47,00	0,63	0,36	3,07	5,64	1,12	6,28	90,05
	Kivihiilituhka Martinlaakso 26.12.-13	0,18	1,57	22,34	57,14	0,70	0,19	2,62	4,82	1,01	5,69	96,25

# XRD: bioash based on wood and peat 70/30

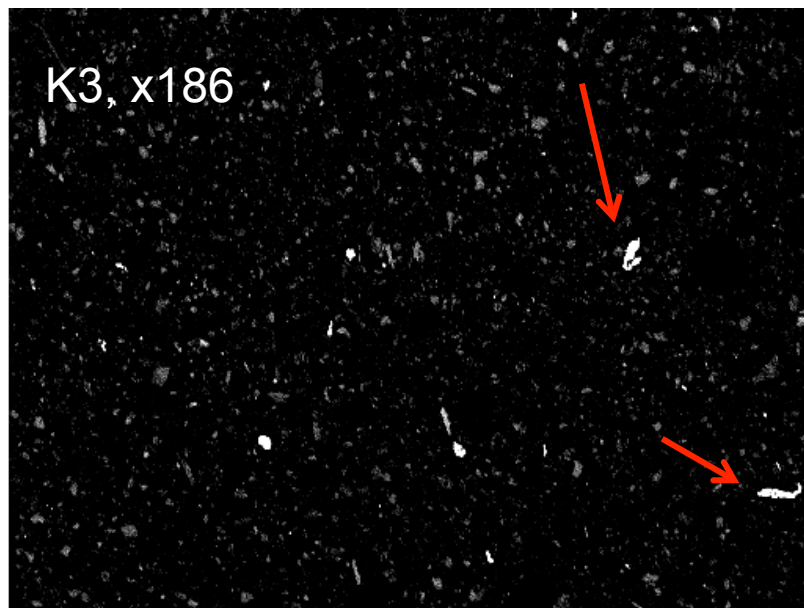
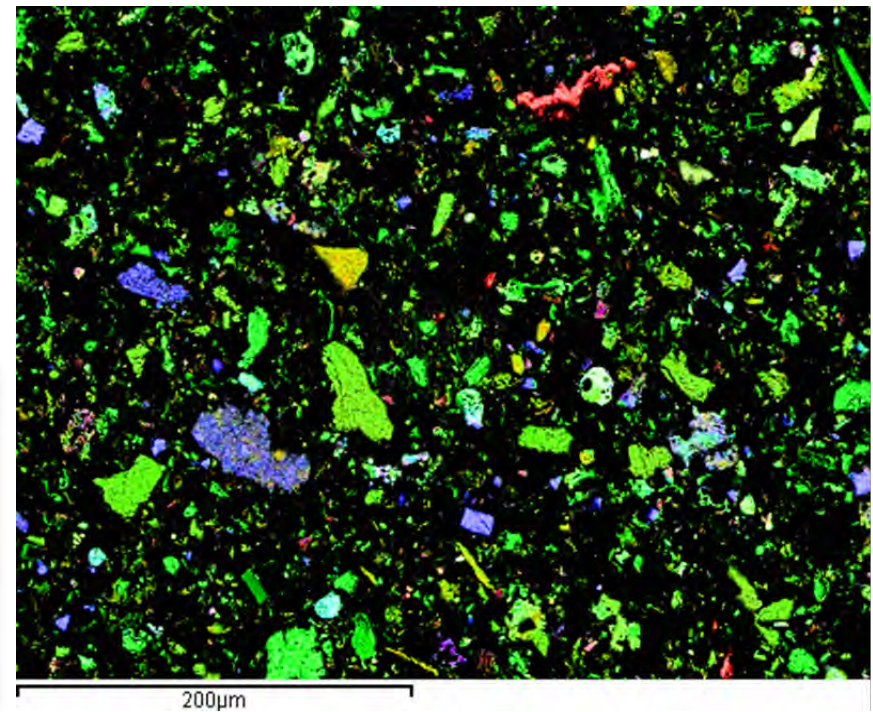


2-Theta - Scale

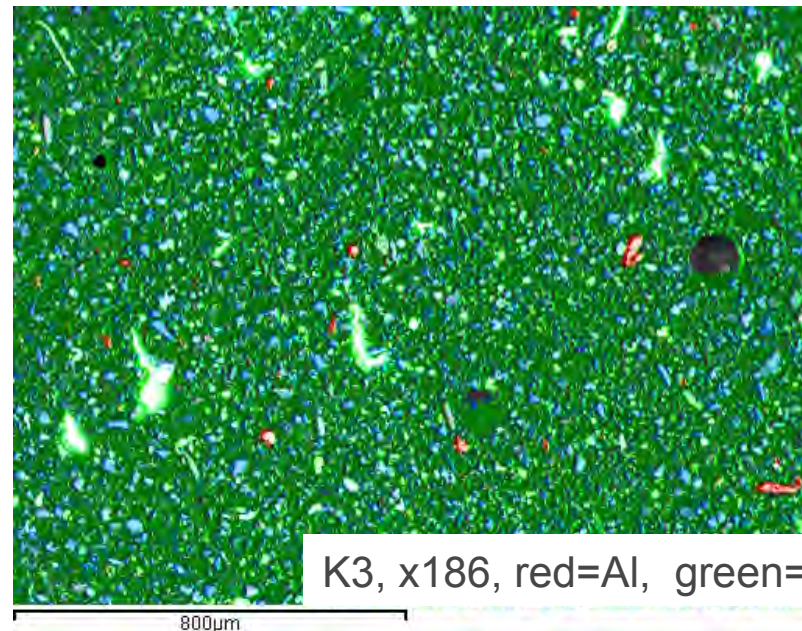
- File: 6-NT-12\_Original-21-3-2014.raw - Type: 2Th/Th locked - Start: 10.000 ° - End: 70.000 ° - Step: 0.04  
 Operations: Background 1.000,1.000 | Import
- 01-087-1787 (\*) - Microcline ordered -  $K(AlSi_3O_8)$  - S-Q 5.5 %
  - 00-050-0146 (\*) - Potassium Magnesium Phosphate -  $KMgPO_4$  - S-Q 1.8 %
  - 01-087-1832 (\*) - Calcium Manganese Sodium Aluminum Silicate -  $(Ca_0.715Mn_0.196Na_0.045)(Al_{1.911}Si)$
  - 01-072-3540 (\*) - Sanidine -  $K(Si_1.2Fe_0.5Al_0.3)(Si_1.81Al_0.19)O_8$  - S-Q 1.5 %
  - 01-089-5969 (I) - Monelite, syn -  $Ca(HPO_4)$  - S-Q 8.7 %
  - 01-072-7417 (\*) - Sodium Calcium Iron Phosphate -  $NaCaFe_3(PO_4)_4$  - S-Q 7.2 %
  - 01-079-0700 (\*) - Calcium Phosphate -  $Ca(PO_3)_2$  - S-Q 8.3 %
  - 01-082-1690 (\*) - Lime, syn -  $CaO$  - S-Q 0.3 %
  - 01-070-3755 (\*) - Quartz -  $SiO_2$  - S-Q 38.6 %
  - 01-089-0835 (I) - Diopside ferrian, syn -  $Ca_{1.007}(Mg_{0.805}Fe_{0.214})(Si_{1.75}Fe_{0.241})O_6$  - S-Q 1.8 %
  - 01-089-4377 (\*) - Grossular -  $Ca_3Al_2(SiO_4)_3$  - S-Q 0.6 %
  - 01-086-2270 (A) - Anhydrite -  $Ca(SO_4)$  - S-Q 4.8 %

# Development of bioash+MK based geopolymer concrete

Some problems ...



Al Ka1

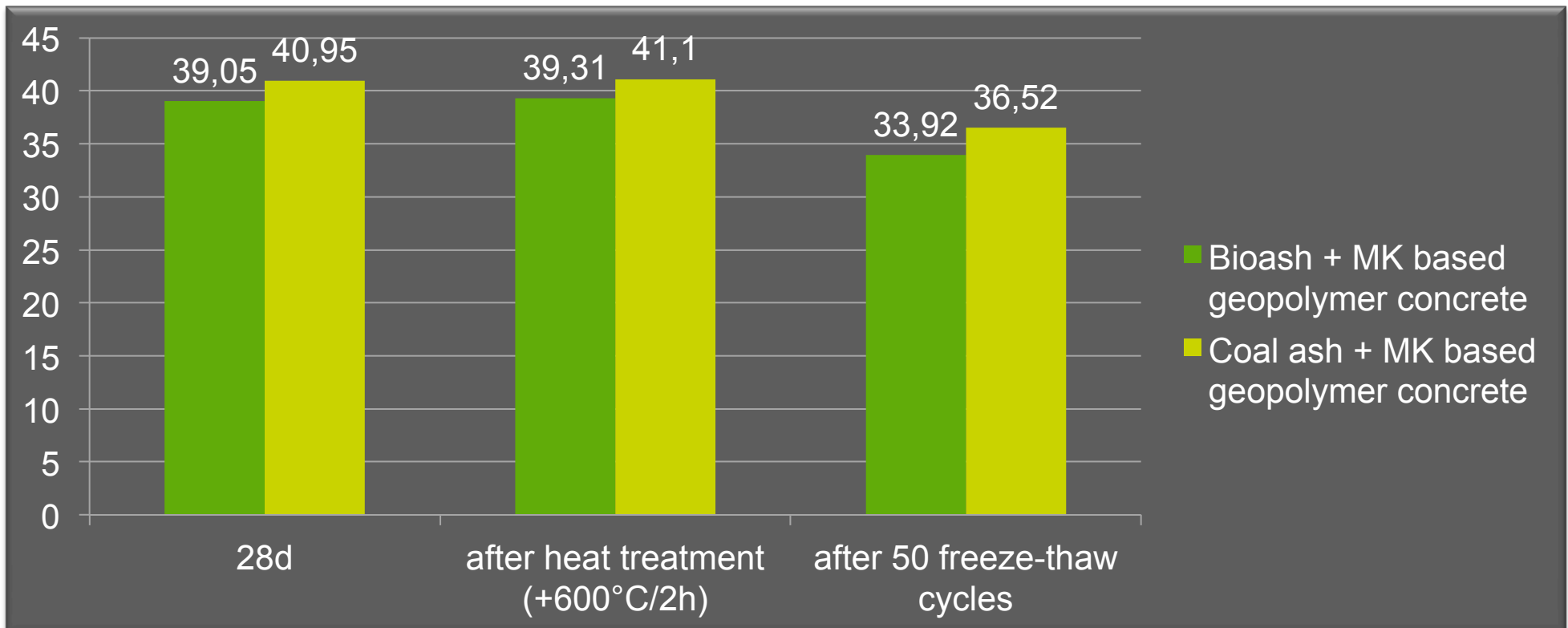


K3, x186, red=Al, green= O, blue=Si

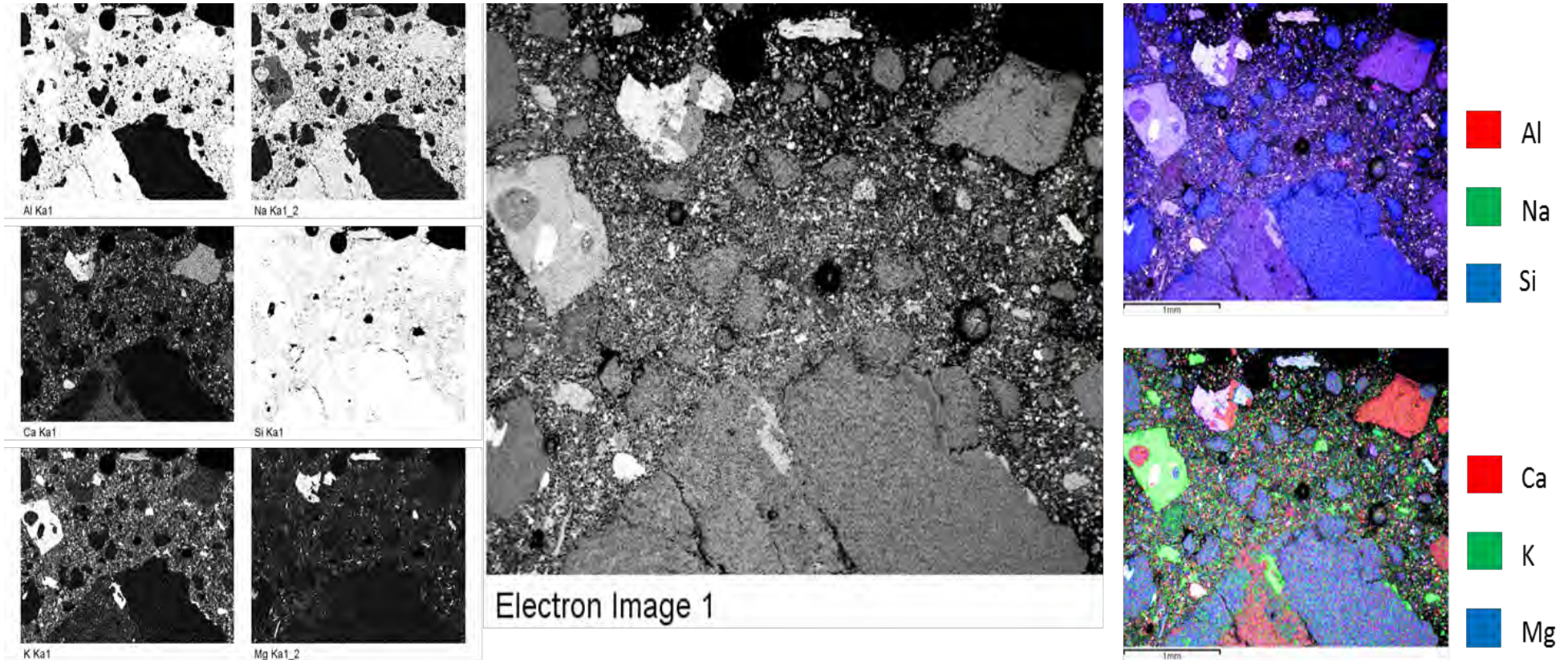
# Development of bioash+MK based geopolymer concrete

...but also relatively good results in comparison with coal fly ash (class F) +MK based geopolymer concrete

- Bioash modified: classified  $>35\mu\text{m}$  and ground  $<45\mu\text{m}$  (d90)



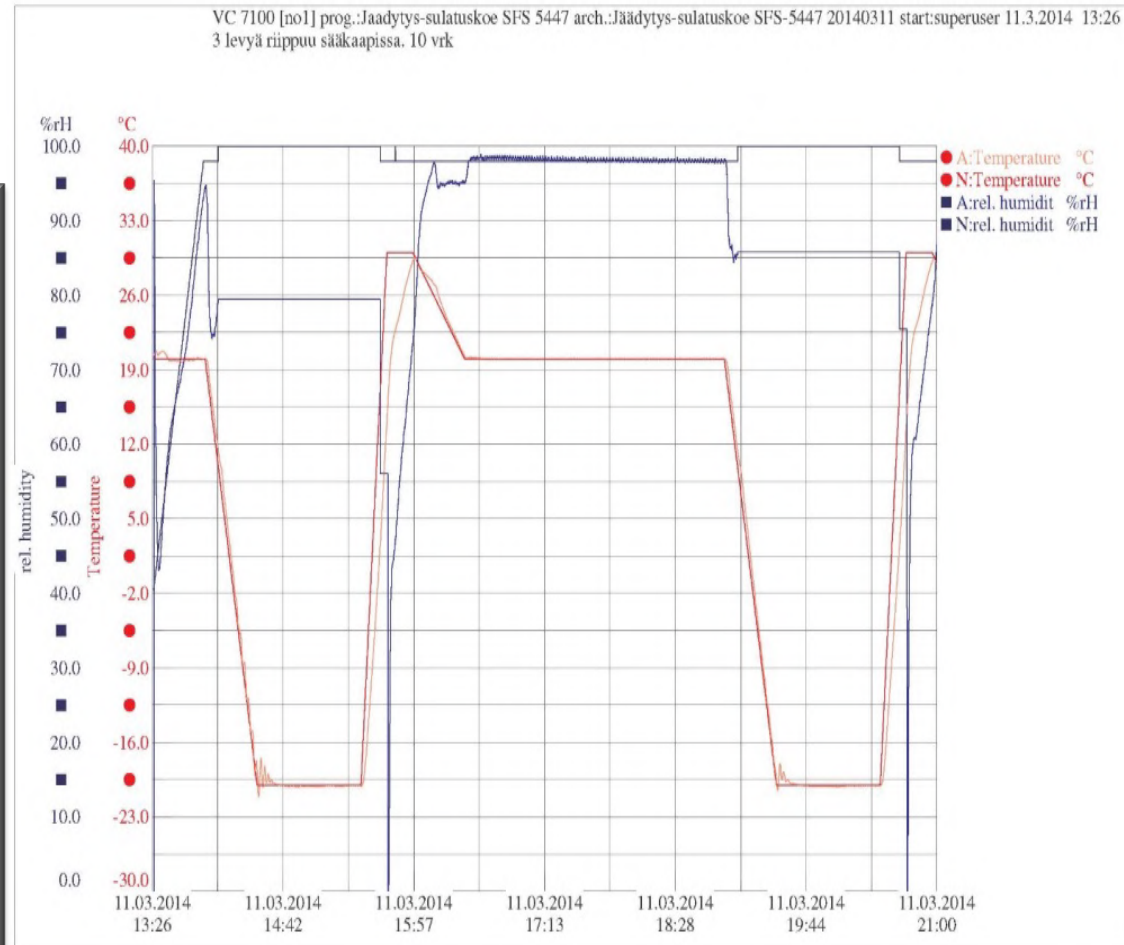
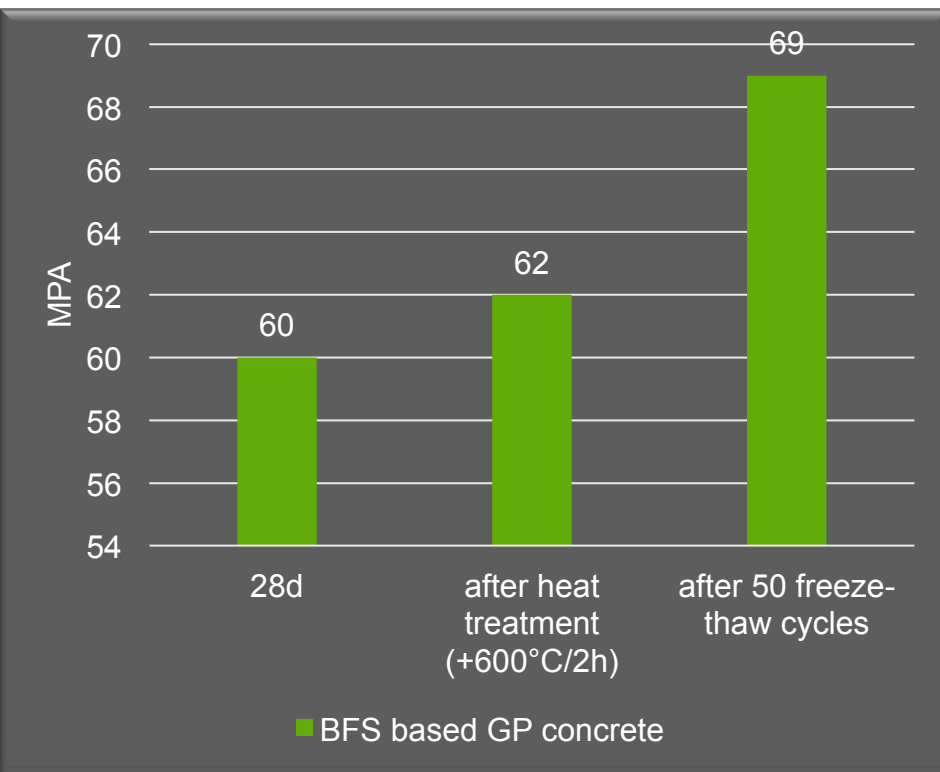
# Bioash +MK based GP concrete x90





# Behaviour of slag based GP concrete after heating and freeze-thaw cycles

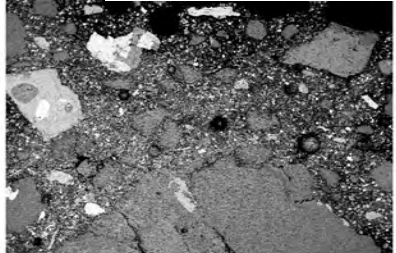
- Curing in dry and room temperature (+18°C)



# Differences in concretes after heat treatment and freeze-thaw cycles

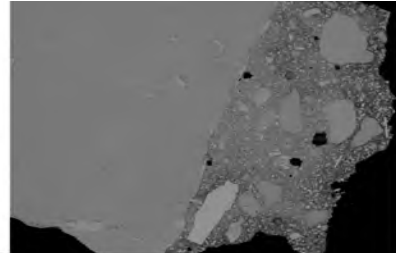
Bioash + MK based GP concrete

after 28d



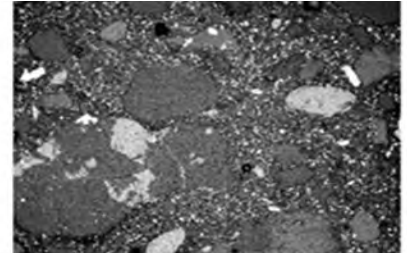
BT-O

after 2h +600°C



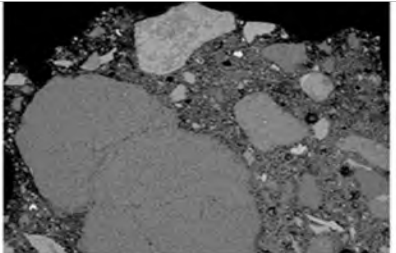
BT-LR

after 50 freeze-thaw cycles

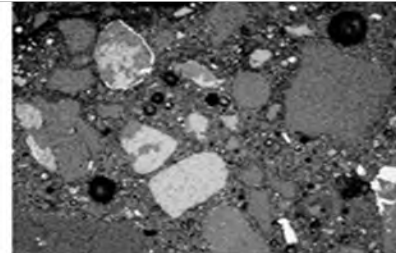


BT-SR

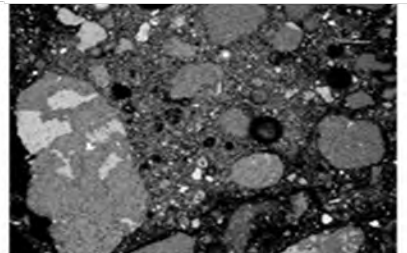
Coal fly ash + MK based GP concrete



KHT-O

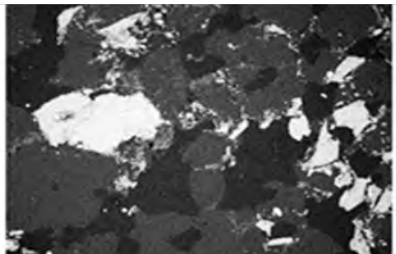


KHT-LR

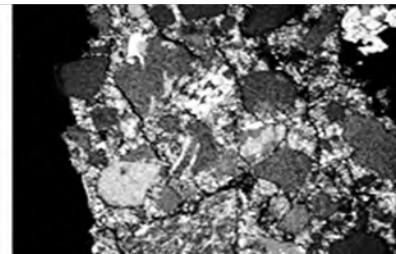


KHT-SR

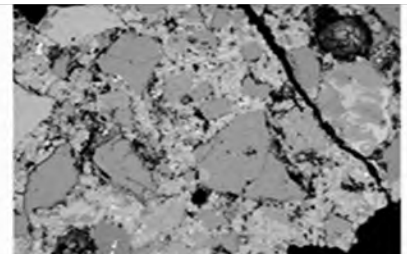
BFS-based GP concrete



MK-O

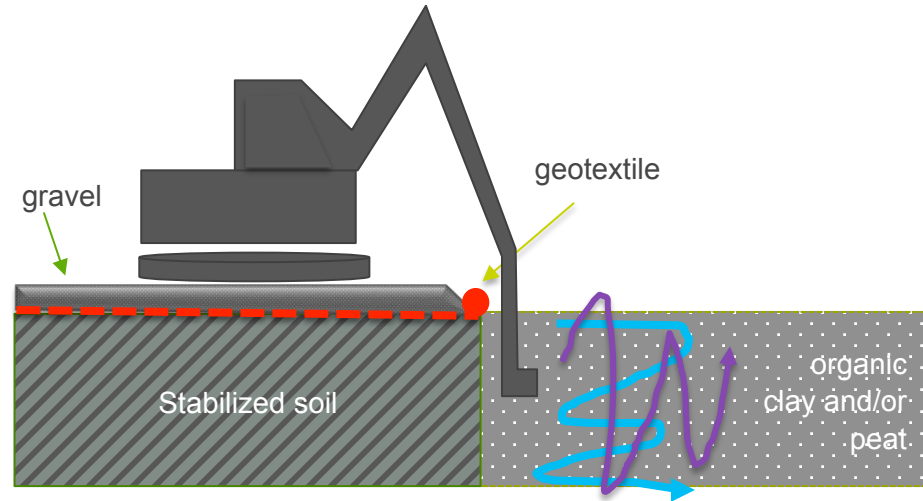


MK-LR

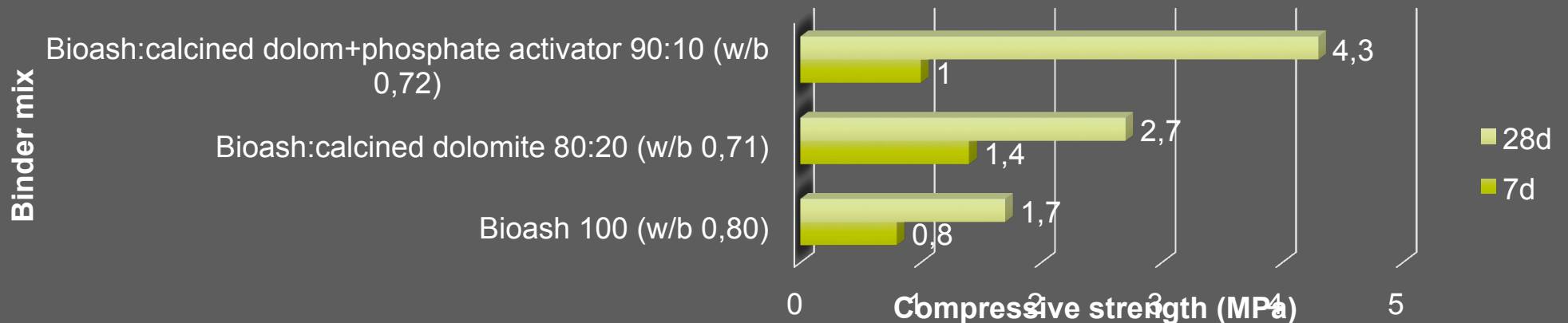


MK-SR

# An example on tests: experimental studies with bioash based mass stabilization binder mixes for road construction



## mass stabilization mix : binder 25% + aggregate 75%





Thank you