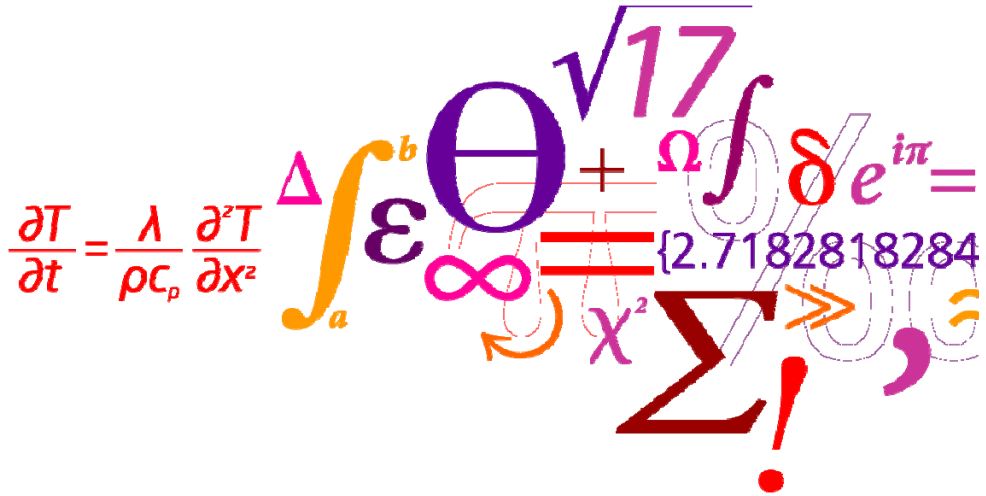
Utilisation of electrodialytically treated sewage sludge ash in mortar

PhD student Annemette Kappel
Post doc Raimon Paréz Viader
Post doc Krzysztof Piotr Kowalski
Associate Professor Gunvor M. Kirkelund
Professor Lisbeth M. Ottosen

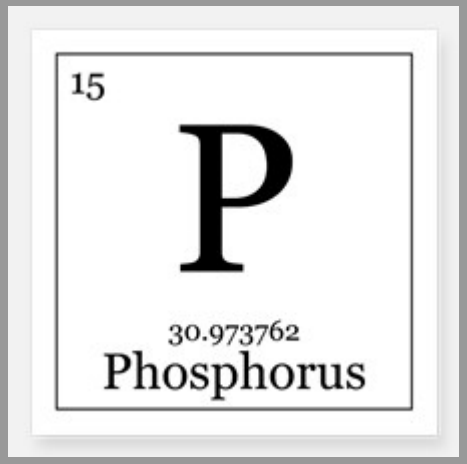
Technical University of Denmark

DTU Civil Engineering
Department of Civil Engineering



Sewage sludge ash (SSA)

- 1.2 mio ton SSA production in North America annually */Cyr et al., 2007/*
- The number of SSA incinerators are increasin */Donatello et al., 2013/*
- In Denmark, currently waste product, that is temporarily disposed of for future extraction



Phosphorous

Phosphorous is an essential nutrient and essential for food production.

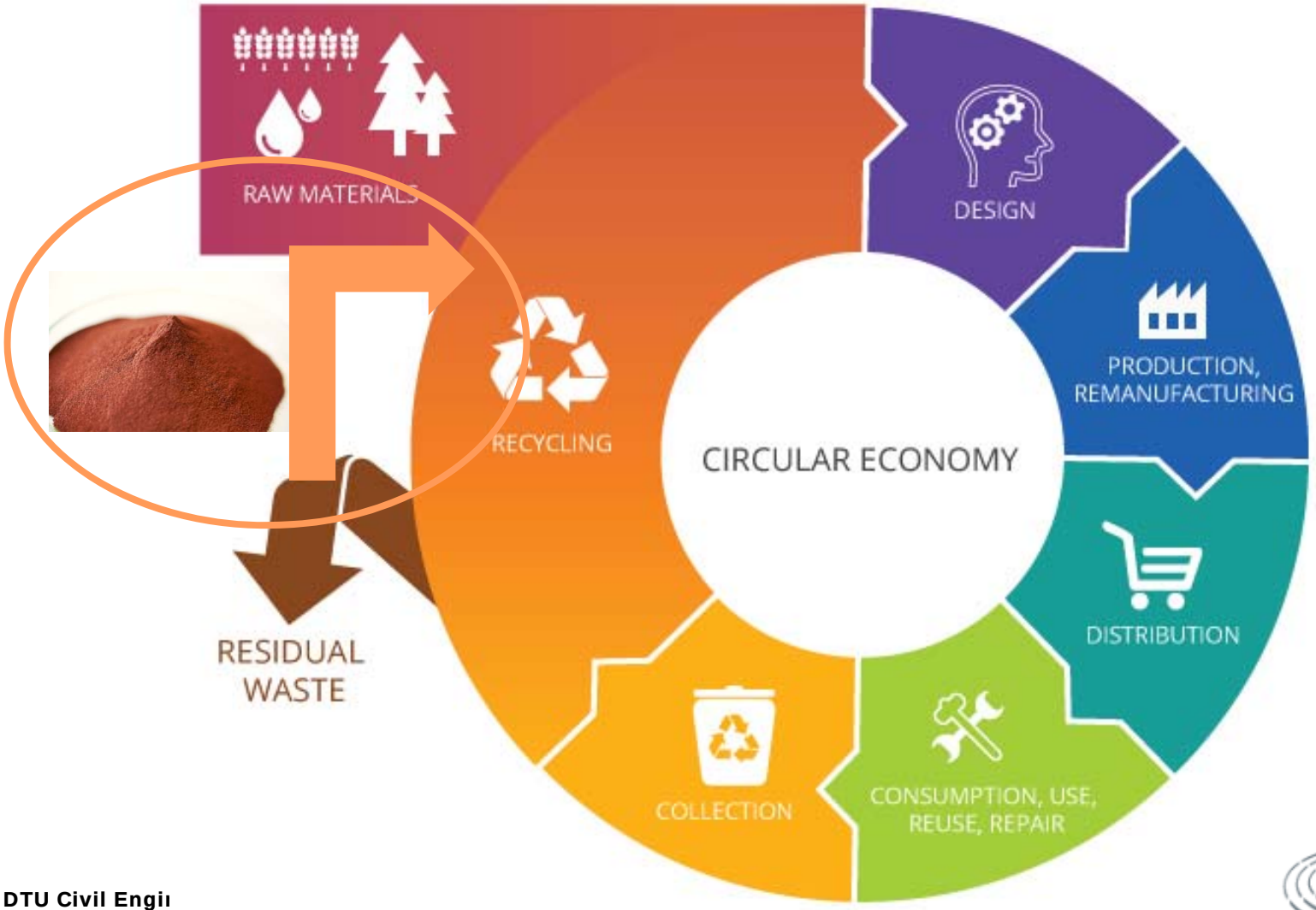
Natural phosphorus sources are depleting

SSA contains 4-15 % P and is an important secondary source -

but P in SSA is not plant available

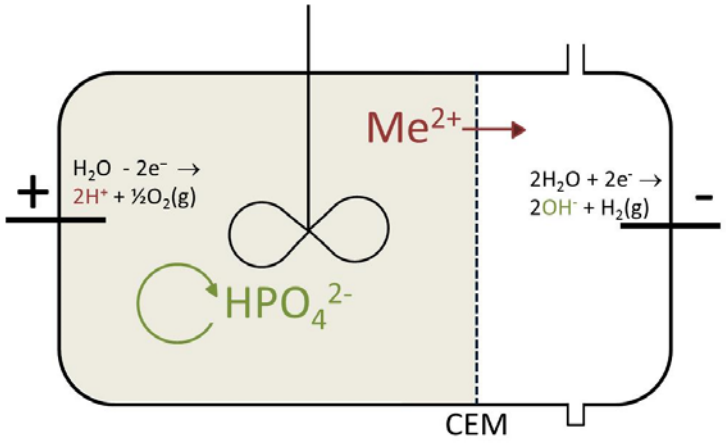
Denmark

Circular economy



Resources in SSA

Electrodialytic separation



Patented: WO2015032903 A1

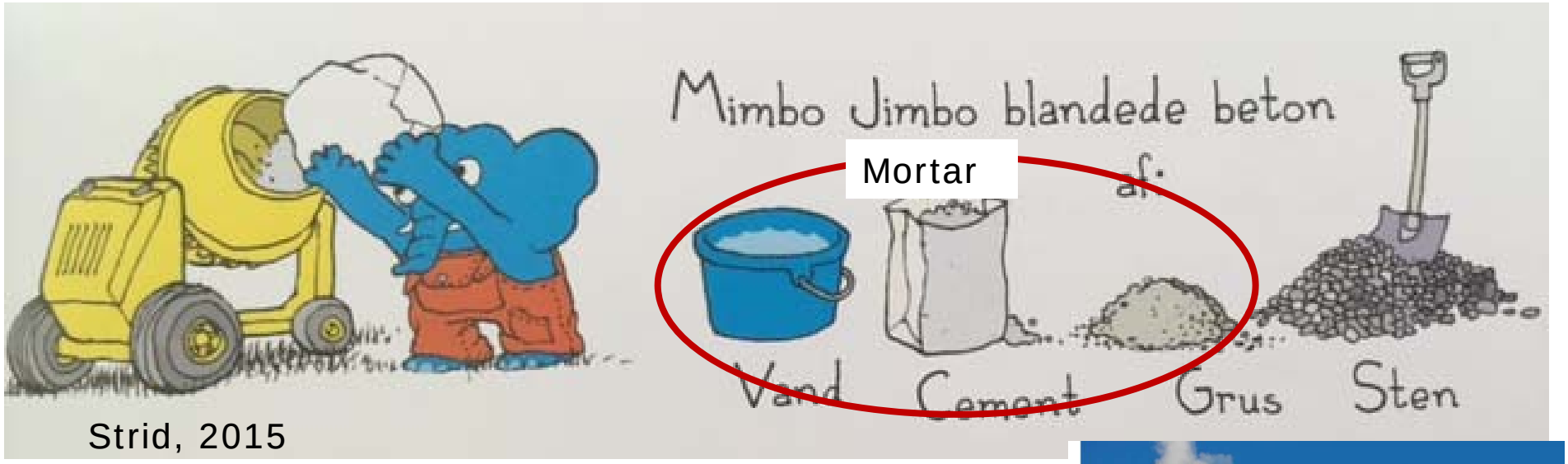
Metal removal

Pure P salt */Ottosen et al. 2016/*

Treated ash as secondary raw material?

Aim of the study

- The aim is to investigate the potential for combining electrodialytic extraction of phosphorous from SSA and the use SSA-ED as cement replacement in mortar

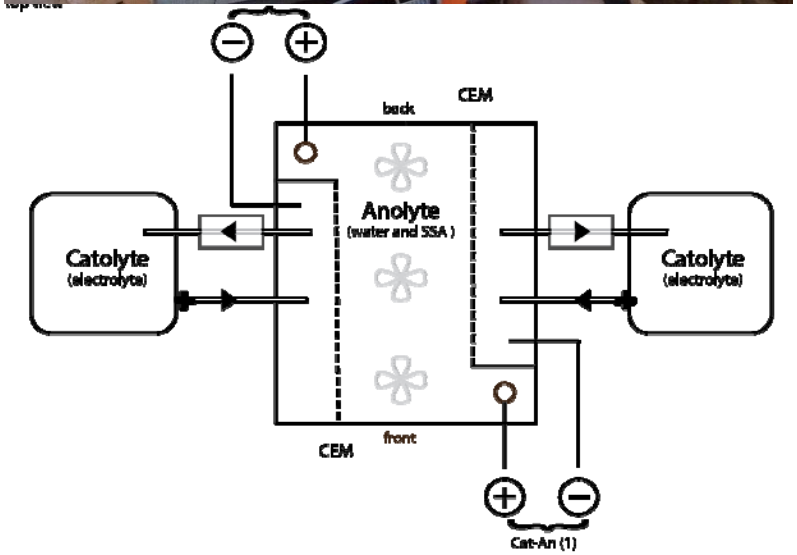


Strid, 2015

- Cement production responsible for 5-7 % of the anthropogenic CO_2- emissions

Electrodialytic bench scale experiment

- Upscaling the laboratory set-up to bench scale
- One electrodialytic experiment with, treating 3 kg SSA in a slurry
- Heavy metals captured in the catholyte and seperated from the P and the residual mineral SSA



Experimental mortars

- SSA used: raw and electrodialytically treated
- The SSAs were grinded to get a more comparable material to cement (30 sec, 10 min)
- A reference mortar and 6 different mortars with 20 % cement replacement by SSA
- The mortars were tested for workability, compressive strength and colour development

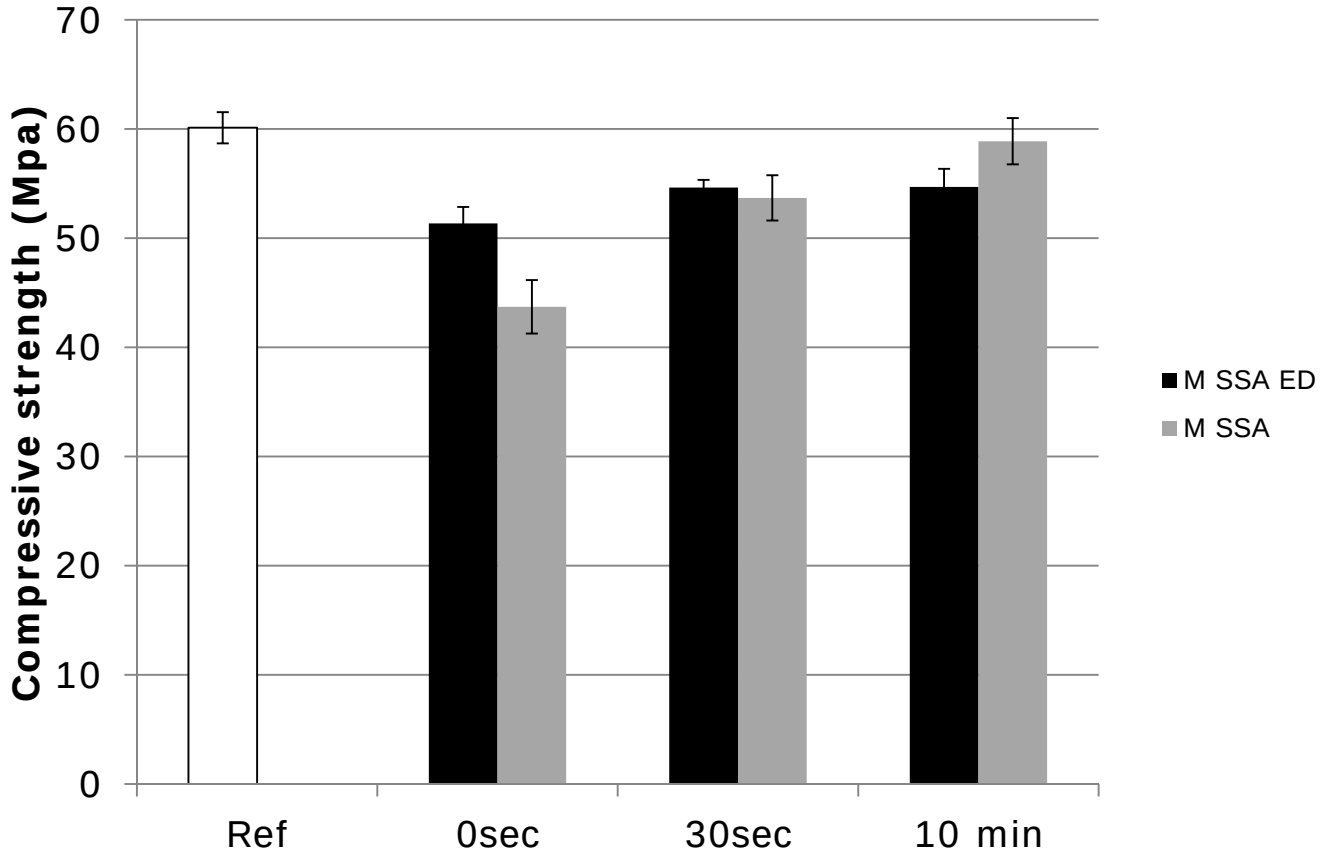


SSA characteristics

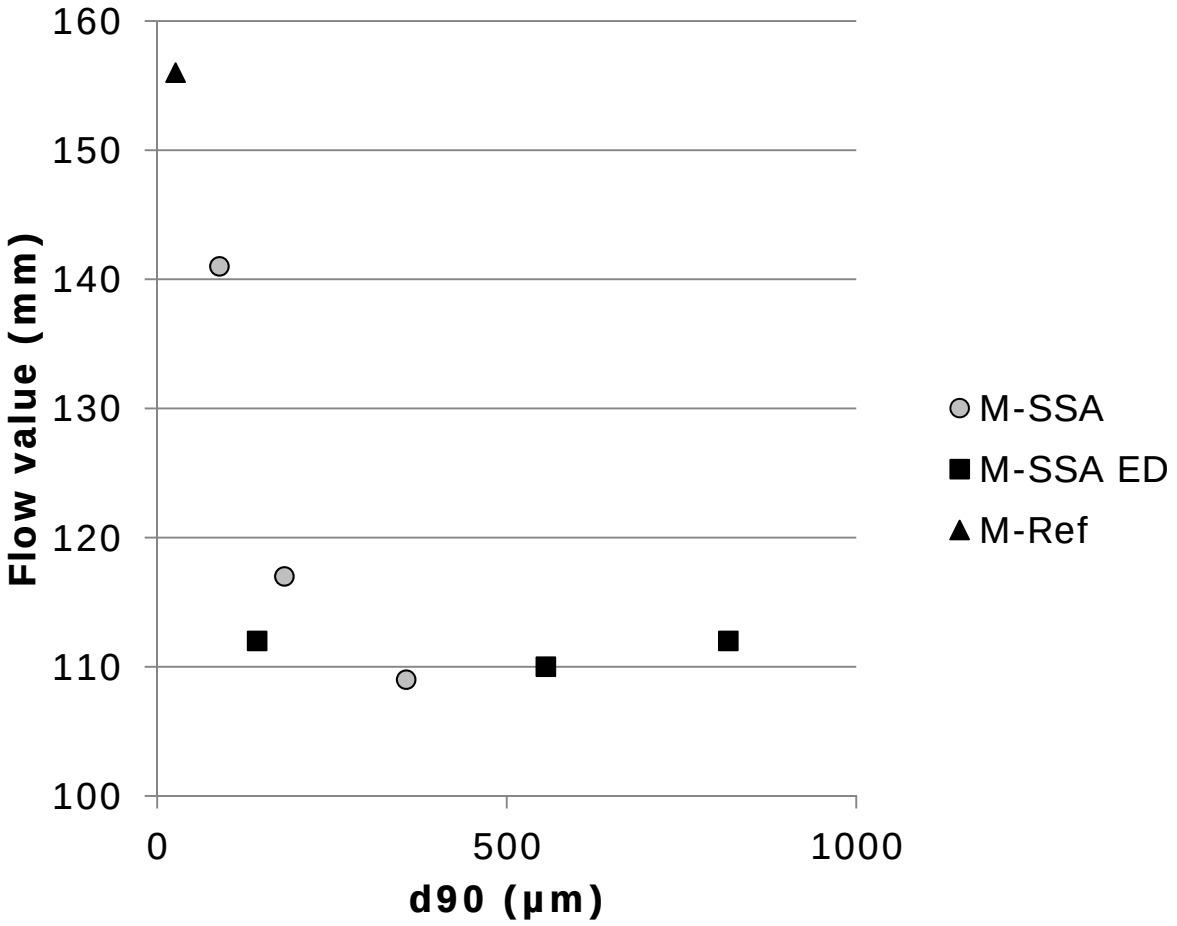
- 90 % P extraction from the ash by the electrodialytic treatment
- Heavy metals removed from the SSA, but higher metal leaching after electrodialytic treatment due to the low pH

	Cement	SSA	SSA-ED	Requirement for coal fly ash (DS/EN 450-1)
pH	12.6	9.3	3.5	
LoI (%)	0.8	0.5	4.4	Max. 5 %
SiO_2+ Al_2O_3+ Fe_2O_3 (%)	40	42	75	>70 %
SO_3 (%)	4.7	19	0.3	< 3 %
Na_2O+K_2O (%)	1.5	2.0	2.6	< 5 %
Cl (%)	0.1	0.02	0.09	Max. 0.1 %

Compressive strength



Workability



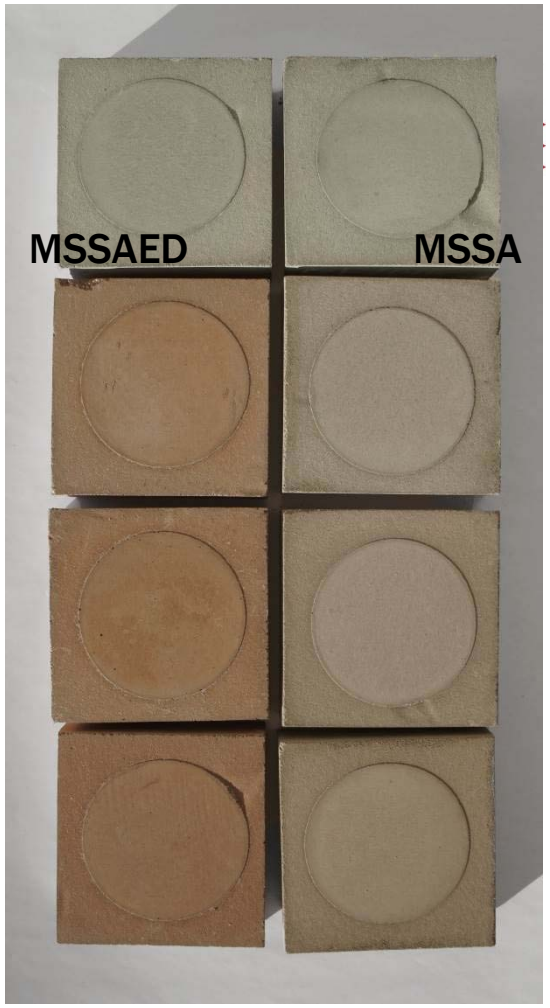
SSA higher porosity

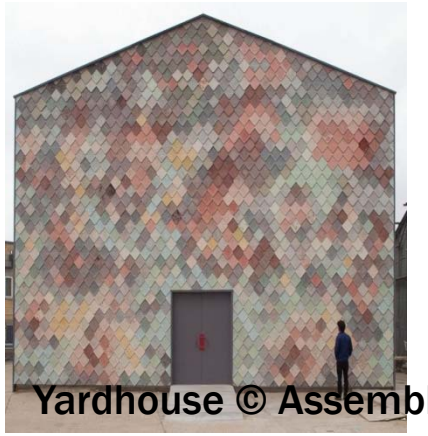
Particle size larger for SSA than cement

Color and texture

- Electrodialytic treatment intensifies the red colour of the ash
- Fe_2O_3 results in the colour and the Fe content was 5.4% in cement, 16 % & in SSA and 27 % in SSAED. Phosphorours can supress Fe colours

- The use of form materials can accentuate the colour
- The rough and smooth surfaces are basic elements of architecture and therefore important for architects and to experience architecture awareness of these elements are necessary




Yardhouse © Assemble

Conclusion

- Electrodialytic separation extracted 90 % of phosphorous from the SSA and the treated residue was acidic

- Lower compressive strengths and workability were achieved for mortars with SSAED compared to the reference mortar

- The distinct colour of SSA can be utilized especially in places where the colour can add aesthetically value to the build environment

- Electrodialytic treated SSA may have potentials to be utilized as a resource in cement based materials and not to be considered as a residual waste after the electrodialytic treatment

Thank you for your attention!

www.zerowaste.byg.dtu.dk

gunki@byg.dtu.dk