LIFE Project Number: LIFE05 ENV/DK/000153

Project BioCrete

Final report (date 080131)

Final report for Task 3

"White bio ash – ash production and concrete trial casting"

Project BioCrete

Task ID: 3
Date: 2008-01-10
Participant: AWS
Name: DK

Preface
"BioCrete" is the acronym for a LIFE supported project "Utilisation of ash from incineration of wastewater sludge (bio ash) in concrete production". The project activities have been defined in 10 tasks, and the present report is the final report for one task, summarising purpose, task progress, results and experiences. The report is written by the task coordinator, as identified by initials for participant and name. The project period is June 2005 to December 2007, and the project includes 4 participants: Avedoere Wastewater Services (AWS) as beneficiary, Lynettefaellesskabet (LYNIS) and Unicon Ltd. (UNICON) as partners and Danish Technological Institute (DTI) as consultants.

Final report for Task 3
"White bio ash – ash production and concrete trial casting"

Introduction
The reddish colour of bio ash concrete produced using the red bio ash from AWS (Avedøre WWTP) has been identified as a significant barrier, when the concrete is to be used for visible materials and constructions, and especially when in combination with normal grey-coloured concrete. The red colour is due to iron compounds in the bio ash, and the purpose of task 3 is to evaluate consequences for the quality of bio ash as well as the bio ash concrete when substituting iron by aluminium for the precipitation of phosphorus during the wastewater treatment.

Background memo
Information on a number of European sludge incineration plants and bio ashes has been collected, see Appendix 1. You find several cases with 'iron bio ash' as well as with 'aluminium bio ash'. However, no statistic material has been elaborated.

Methods and task progress
Because Damhusåen WWTP had occasional experience of replacing the normally used iron (JKL from Kemira Miljø A/S) by aluminium (PAX-14 from Kemira Miljø A/S) for the precipitation of phosphorus, the plan was continuously to operate this WWTP using the aluminium precipitant during a sufficient time in order to replace the iron (from the precipitant) by aluminium in the final digested sludge. As a rule-of-thumb, this is almost the case after a period of 3 sludge ages.

The sludge age was the sum of the sludge ages of the activated sludge and the digested sludge, and in total this turned out to be approx. 60 days. Thus, the period using aluminium precipitant had to be approx. 3 times 60 days or 6 months. Using aluminium is normally more expensive than using iron (in Denmark), and the cost difference has been estimated, see the calculation in Appendix 2.

The period using aluminium precipitant started 2006-02-09 and ended 2006-08-10. The plant operation was satisfactory during the entire period, i.e. with no technical or process related problems. Samples of sludge cake (dewatered digested sludge) were analysed for iron and aluminium at the start, the end and half way through the period, see Figure 1. It shall be noted that the concentration of iron does not approach a value of zero, because there are other sources than JKL to the iron in the wastewater and the sludge.

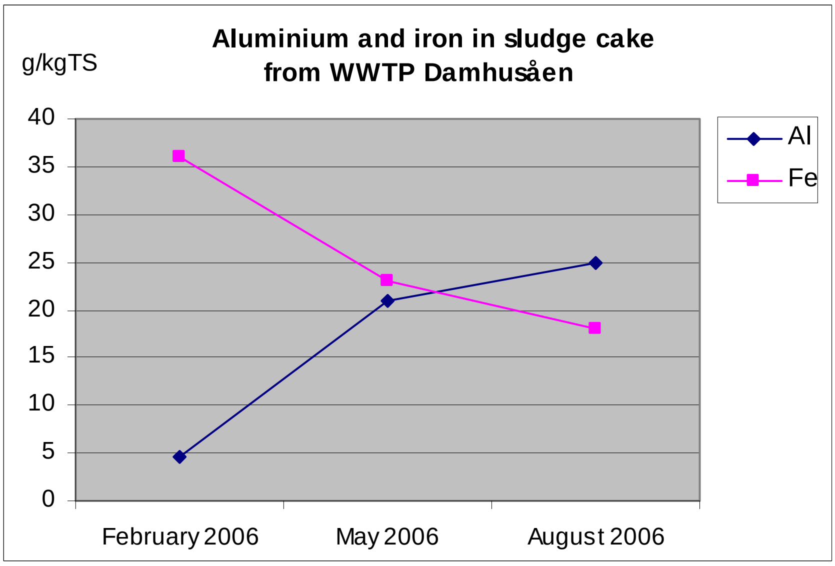

Figure 1. Development of sludge cake with less iron for the production of "white bio ash".

During a week around 2006-08-10, approx. 150 m^3 of fresh sludge cake from Damhusåen WWTP was transferred to an empty sludge silo at the incineration plant at Avedøre WWTP, see Figure 2.

Figure 2. Transfer of sludge cake from Damhusåen WWTP to the incineration plant at Avedøre WWTP. 2006-08-10.

This time of the year was chosen, because the incineration plant was empty and 'clean' after the regular planned summer shut down for check ups and repairs. Thus, the sludge cake from WWTP Damhusåen was the very first batch to be incinerated after the summer period. The incineration took place on 2006-08-18 and approx. 10 t of "white bio ash" was 2006-08-21 transferred from the ash silo to one of the UNICON factories (as well as approx. 200 kg to DTI).

The white bio ash has afterwards been characterized in parallel with other bio ash samples according to the test programmes in task 4, 5 and 6 at DTI and task 8 at UNICON. The "white bio ash" is not white, however less coloured than the 'normal' iron based red bio ash. Thus, the ash has been renamed: the word white has been changed to 'light'.

Results

The most important parameter for this task is the colour. Further, the light bio ash concrete has been tested for technical and environmental properties.

The colour of bio ash. In the 'light bio ash' the major part of the iron content has been replaced by aluminium, and the colour is now lighter and more brownish/yellowish than the red 'iron bio ash' colour, see Figure 3.

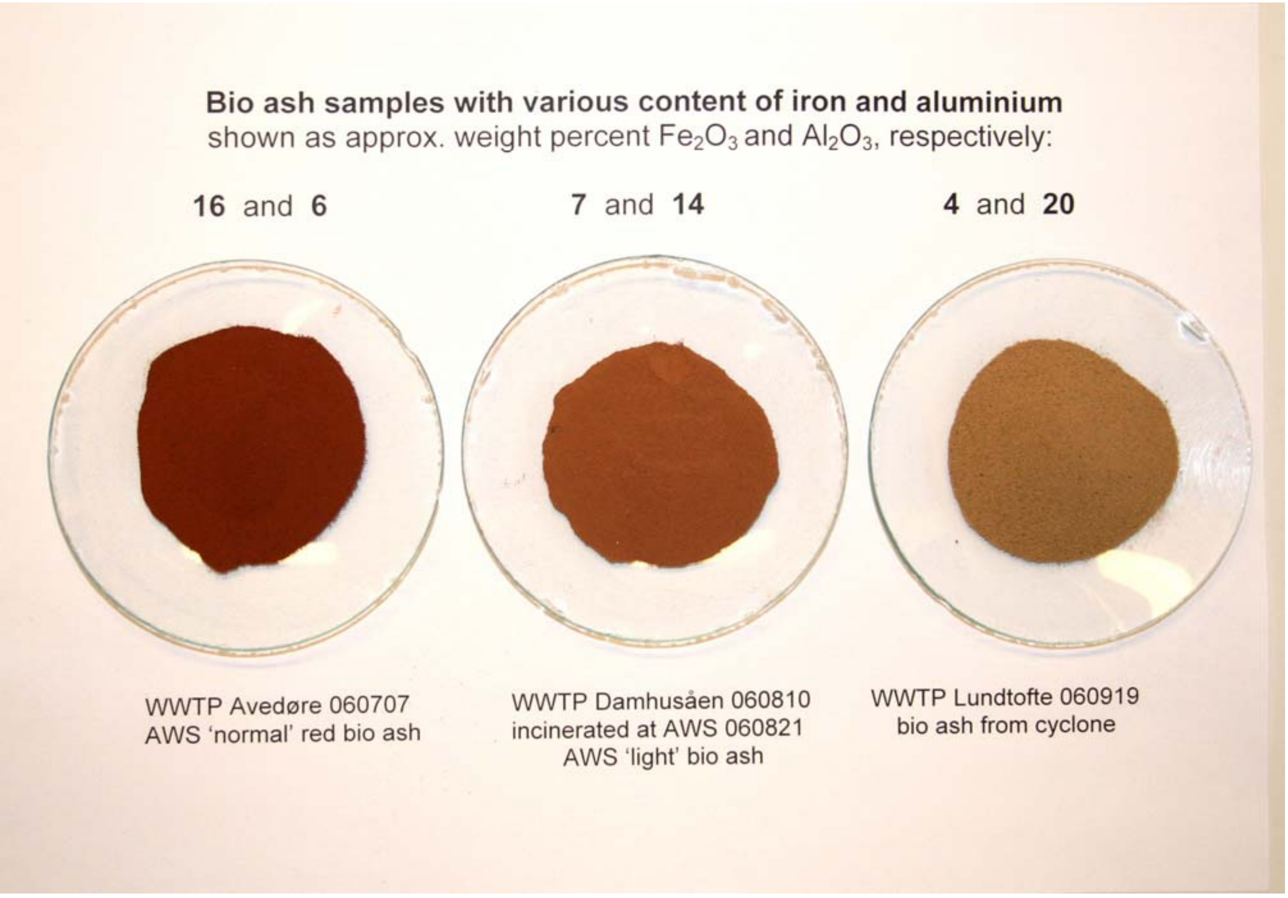

Figure 3. The colour of 3 bio ash samples and the content of iron and aluminium.

The colour of bio ash concrete. Several slabs of bio ash concrete have been cast during the past years. It has been noticed, that bio ash concrete has a nice warm reddish colour, but quite different from the 'cold' grey colour of reference concrete. Further, it is the impression that the bio ash concrete colour becomes paler with time, may be especially if the slabs are placed outdoor. In Figure 4 are shown concrete slabs with red and light bio ash (both with 85 kg/m^3 bio ash and no fly ash) as well as a reference slab (no bio ash and 70 kg/m^3 fly ash).

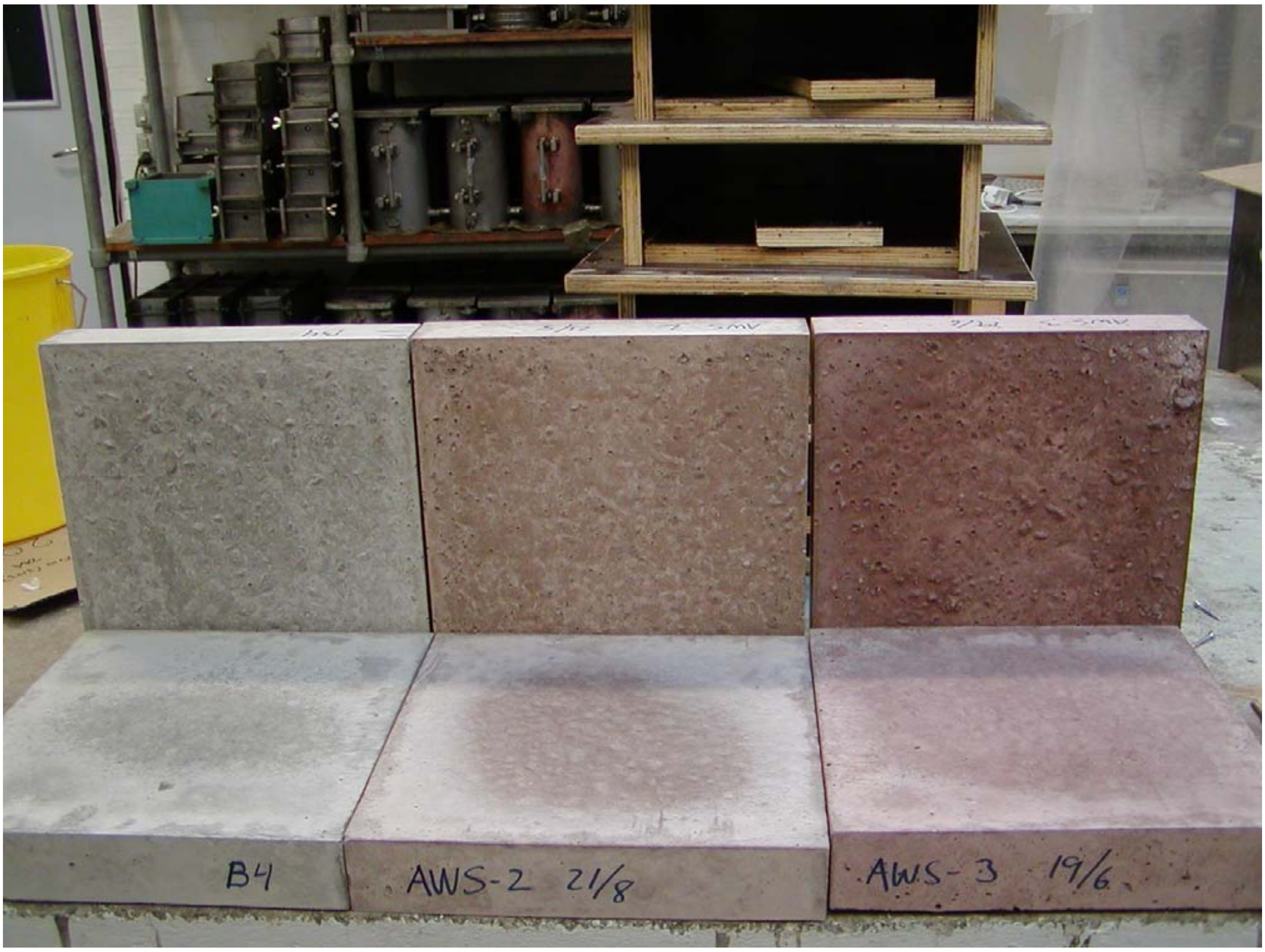

Figure 4. Concrete slabs with 1) no bio ash, 2) light bio ash and 3) red bio ash. 070619.

The colours of these slabs have also been characterized using a RGB instrument by measuring the Hunter L, a and b values on the dates 070629 and 071101. The reflectance is the same for 1) and 2), while lower (i.e. the slab looks darker) for 3). The colour is measured to be red-yellowish for 2) and 3) (no surprise), and just a little greenish for 1).

The repeated measurements after 4 months of indoor conditions did not show any change of colour. The actual values indicate that the bio ash concrete slabs may be now are a little paler; the differences, however, are not significant, see Appendix 3 (to which the mix designs for the slabs are added).

Correlation between concrete colour and content of red or light bio ash. Slabs according to a series of recipes with decreasing amounts of red bio ash from AWS have been produced and studied; see the Final report for Task 8. The conclusion with respect to colour is that even an amount of 15 kg of red bio ash per m^3 is noticeable as a slight reddish colour of the bio ash concrete slabs. Further, it was noticed, that an increased level of cement (approx. 330 kg/m^3 in stead of 210 kg/m^3) seems to weaken the reddish colour. It was concluded, that up to 5 – 10 kg/m^3 of red bio ash has no adverse effect on the colour of the bio ash concrete.

The colour of light bio ash concrete is weaker, but obvious at a bio ash content of 85 kg/m^3; see Figure 4. However, UNICON has reported no adverse effect with respect to colour when producing bio ash concrete with approx. 50 kg/m^3 of light bio ash. It is concluded that up to 20 – 40 kg/m^3 of light bio ash will be acceptable.

Comparison of red and light bio ash. In Figure 5 is shown analytical data (from the Task 4 program) for parameters for which there is a significant difference between the 2 types of bio ash. Besides the different levels for iron and aluminium content, and the different colours, the absence of haematite in the light bio ash is noteworthy. When comparing, it must be considered, that the two types of bio ash originate from the sludge from two different WWTPs (but the incineration took place at the same incineration plant).

Analytical parameter			Bio ash	
Name	Unit	Method	Red	Light
Colour			red	light brownish
Soluble phosphate	mg/kg*	Annex C*	75	30
Silicon dioxide (SiO_2)	%	EN 196-2	23	35
Reactive silicon dioxide (SiO_2)	%	EN 197-1	12	15
Calcium oxide (CaO)	%	EN 196-2	20	16
Iron oxide (Fe_2O_3)	%	EN 196-2	16	7
Aluminium oxide (Al_2O_3)	%	EN 196-2	6	14
Sum of SiO_2, Al_2O_3 & Fe_2O_3	%	EN 196-2	45	54
Phosphorus as P_2O_5	%	WDXRF	27	22
Calcium as CaO	%	WDXRF	21	16
Silicon as SiO_2	%	WDXRF	21	29
Amorphous	%	QXRD	55	63
Calcium phosphate	%	QXRD	19	14
Quartz (crystalline SiO_2)	%	QXRD	10	15
Haematite (crystalline Fe_2O_3)	%	QXRD	6	< 1
Particle density	kg/m^3	EN 196-6	2820	2640

* Annex C in EN-450-1:2005; the analysis expresses mg "available phosphorus pentoxide" (P_2O_5) per kg ash

Figure 5. Characterization of red and light bio ash. Selected parameters.

Comparison of other qualities (than colour) of red and light bio ash concrete. The sample of light bio ash (AWS 060821) has been included in the test programmes for bio ash concrete described in Task 5, 6 and 8, and the comparable data for red bio ash concrete and light bio ash concrete can be found in the Final Reports for these tasks.

In general there is little or no difference between the qualities of the two types of bio ash concrete. The compressive strength seems to be a little higher for the light bio ash concrete (see Task 6 and Task 8), while there are no differences when comparing the concentrations of heavy metals in the leachates (see Task 5).

Discussion and conclusion

It turned out to be possible to operate Damhusåen WWTP for half a year using an aluminium precipitant (for the removal of phosphorus) in stead of an iron precipitant, and afterwards to transfer 150 m^3 of sludge cake to be incinerated at AWS (Avedoere WWTP), thus producing 10 t of 'light bio ash' (or aluminium bio ash).

The colour of this light bio ash is yellow-brownish and lighter than the 'normal' red bio ash (or iron bio ash). The colour of the bio ash is related to the iron content; however, not only to the total iron content, but definitely also to the structure and mineralogy of the ash. It seems very likely that the red colour is related to the content of haematite (crystalline Fe_2O_3); see Figure 5.

The colour of two aluminium bio ashes is yellow-brownish, see Figure 3, very different from the (light) grey colour of fly ash, although the (total) content of Fe_2O_3 in fly ash is 4 – 9 weight percent, i.e. similar to the two aluminium bio ashes. The explanation is most likely the different structure of the ashes: Fly ash consists of small glassy spheres produced by the incineration of coal at a temperature of approx. 1300 ^{0}C, while bio ash consists of fine porous particles produced by the incineration of WWTP sludge cake at a temperature of approx. 850 ^{0}C.

As an ingredient in concrete mix designs (recipes), the light bio ash is technically just as good (or even a little better) than red bio ash, and much better with respect to the discolouring of bio ash concrete. The limit contents for no adverse colour effect seem to be 20 – 40 kg/m^3 for light bio ash and only 5 – 10 kg/m^3 for red bio ash.

European sludge incineration plants produce iron bio ash as well as aluminium bio ash. The choice of precipitant for the removal of phosphorus at the WWTP's depends on process performance as well as economy. Iron is normally the choice in Denmark.

Contact

For a more detailed information or discussion, everybody is welcome to contact the partner sites. Please find our contact data via the project home page: www.biocrete.dk.

Appendices

1. "Chemical composition of European bio ashes". Memo of 071221.

2. “Calculation of cost difference between the use of Aluminium and Iron for the precipitation of phosphorus at the WWTP of Damhusåen”. Note of 071221.

3. (In Danish) “Farvemåling af fliser fra BIOCRETE”. Note of 071102.

LIFE Project Number: LIFE05 ENV/DK/000153

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Appendix 1

"Memo: Chemical composition of European bio ashes"

Project BioCrete

Task ID: 3a
Date: 2007-12-21
Participant: AWS
Name: DK

Memo: Chemical composition of European bio ashes

Introduction

The purpose of the BioCrete project is to increase the reuse of bio ash (sewage sludge incineration ash) for the production of concrete by improving the characterization and documentation of technical and environmental properties of bio ash concrete. The tests and the examinations of bio ash concrete have been performed on samples with bio ash from two different Danish WWTPs.

The used types of Danish bio ash have been analyzed as part of the project, and in order to evaluate how these types compare to other European bio ashes, an effort has been made to collect analytical bio ash data from a number of European WWTPs with sludge incineration.

Method

Using our own network as well as new useful contacts established during the conference in Moncton June 2007[1] requests and questionnaires have been sent to contact persons at institutes or WWTPs in Austria, Denmark, England, France, Germany, Holland, Italy and Switzerland.

We got answers from most contact persons. Not all were able to supply us with data, mainly because they did not analyze the ash (or may be only heavy metals). Others gave us data, but preferred to be anonymous (except for the country). For 5 of the ash samples (ID no. 2, 4, 5, 6 and 16) the received information and identification is presented in the questionnaire format, and for all 17 samples, most of the received chemical analytical data are shown in the table 1 (next page).

It must be emphasized that the data should be considered just to give an order of magnitude. No attempt has been made in order 'dig in' behind the data, i.e. evaluate possible differences between the WWTP sludges, sampling routines and the used analytical methods, preconditions which do influence the comparisons.

Results

The chemical composition of the 17 samples of European bio ash is quite uniform and consistent.

With respect to the abundant elements, phosphorus is an important component, because a major purpose of WWTPs is to remove phosphorus from the wastewater; the typical level is 15 – 25 weight percent as P_2O_5. This removal is partly based on the hardness of the water, i.e. calcium (and magnesium), and mainly on the addition of iron or aluminium salts. Thus, some ashes are high in iron content and low in aluminium content – and vice versa. A high content of calcium can be attributed to the use of alkaline calcium compounds for the cleaning of the incineration flue gas.

The sum of the oxides of silicon, aluminium and iron is shown in the table, because this is used as a quality parameter for the use of fly ash for concrete production.

The levels for the more important heavy metals also seem to be quite consistent, mercury being the only exception. In general, sludge incineration plants produce a primary ash with < 0.1 mg/kg mercury and remove mercury from the flue gas in a second stage. However, in some cases the mercury containing secondary ash or residue is disposed of together with the primary ash.

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[1] IWA Specialist Conference on Wastewater Biosolids. Moncton, New Brunswick, Canada. 24-27 June 2007, where the BioCrete project was presented as a Danish case study.

Avedoere Wastewater Services 10. December 2007. DK/dk
J.no. UD-0350-0033. BioCrete. Task 3a

Memo: Chemical composition of European bio ashes. Table 1

Analytical Parameter		Bio ash sample ref. ID number and origin (country)																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Name	Unit	EU	DK	DK	DK	DK	NL	NL	NL	DE	DE	DE	CH	CH	CH	CH	FR	UK
Iron as Fe_2O_3	% w/w	10	15	6,5	11	4,1	16	5	16	2,8	23	21	27	3	14		4	
Aluminium as Al_2O_3	% w/w	10	6,5	13	8	20	6,5	9	6,5	15,5	6,5	6,5	8	34	13		11	
Fe/(Fe+Al)	w/w	0,6	0,8	0,4	0,6	0,2	0,8	0,4	0,8	0,2	0,8	0,8	0,8	0,1	0,6		0,3	
Silicon as SiO_2	% w/w	35	23	35	28	31	22	19	23	38	24	21	25	25	15		38	
$SiO_2 + Al_2O_3 + Fe_2O_3$	% w/w	56	45	55	47	55	45	33	46	56	53	48	60	62	42		53	
Calcium as CaO	% w/w	23	20	16	14	14	16	19	13	16	15	12	14	11	32		20	
Phosphorus as P_2O_5	% w/w	16	27	22	24	18	24	25	23	20	19	25	20	20	9	14	15	
Zinc as Zn	mg/kgTS		1800	1500	2300	1700	2300	2100	2200	1800	2200	1600	1800	2400	1200	2600	3000	3700
Copper as Cu	mg/kgTS		700	450	600	600	1100	1000	1000	950	1250	500	550	900	750	900		1200
Lead as Pb	mg/kgTS		120	180	170	130	270	200	260	120	135	110	270	250	550	170	450	1100
Chromium as Cr	mg/kgTS		90	40	50	40	120	110	130	70	90	90				110	150	700
Nickel as Ni	mg/kgTS		75	45	40	28	70	75	100	45	40	40				60		140
Arsenic as As	mg/kgTS		15	11	4		22	17	40	13	16	4					15	50
Cadmium as Cd	mg/kgTS		5	3	3	3	4	3	4	4	3	2				3	7	8
Mercury as Hg	mg/kgTS		4	7	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	0,2	< 0,1	< 0,1				< 0,1	10	5

Country code
CH Switzerland
DE Germany
DK Denmark
EU 'Europe'
FR France
NL Holland
UK England

Ref. ID	
1	Average/typical data for 15 European ashes, see Christian Schaum paper in Moncton IWA Conference Proceedings p. 583
2-4	The "BioCrete" Project: 2 AWS, 3 light bio ash (see task 3b), 4 LYNIS, see questionnaires for no. 2 and 4
5	Sabina Lind personal communication: see questionnaire for no. 5
6	Leon Korving personal communication: see questionnaire for no. 6
7-11	Christian Adam personal comm.: Data from table 1 in paper (september 2007) from the "SUSAN" project
12-14	Simone Nanzer personal comm.: Data for 3 types of ashes (Fe, Al and Ca) from the "PHOSKRAFT" project
15	Natalija Miladinovic personal comm.: Data from the "NEPTUNE" project
16	Typical data from 4 French incineration plants, see questionnaire for no.16
17	Mike Farrimond (from UKWIR) personal comm.: Average/typical data for approx. 10 English incineration plants

Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants
(Bio ash ID no. 2)

1. Contact

1.1 Name of plant: *Avedoere Wastewater Services (Spildevandscenter Avedøre I/S)*

1.2 Town and country: *Copenhagen, Denmark*

1.3 Contact person: *Dan Kjersgaard*

1.4 Phone and e-mail: *+45 3634 3854. dk@spvand.dk*

1.5 Homepage: *www.spildevandscenter.dk*

2. Wastewater Treatment Plant

2.1 Load (e.g. PE_{BOD60}): *250.000 PE_{BOD60} and 26.000.000 m^3/year (2006).*

2.2 Main processes: *Mechanical, biological/chemical treatment, mesophilic sludge digestion.*

2.3 Precipitant for P removal: *Fe as $FeClSO_4$-solution, i.e. iron in the oxidation state of +3.*

2.4 Additional comments: *The wastewater composition: 75% household and 25% industry.*

3. Sludge Incineration Plant

3.1 Type of process: *Fluid-bed oven operated at 850^0C; electro filter and bag filter.*

3.2 Amount of ashes: *2.200 t/year (2006).*

3.3 Ashes disposal/use: *50% for controlled land filling and 50% for concrete production (2006).*

4. Analytical data for the ashes *Average values 2006*

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
Iron as Fe_2O_3	*% w/w*	*15*	*Zinc as Zn*	*mg/kg*	*1800*
Aluminium as Al_2O_3	*% w/w*	*6,5*	*Copper as Cu*	*mg/kg*	*700*
Silicon as SiO_2	*% w/w*	*23*	*Lead as Pb*	*mg/kg*	*120*
Calcium as CaO	*% w/w*	*20*	*Chromium as Cr*	*mg/kg*	*90*
Phosphorus as P_2O_5	*% w/w*	*27*	*Nickel as Ni*	*mg/kg*	*75*
			Cadmium as Cd	*mg/kg*	*5*
			Mercury as Hg	*mg/kg*	*4*

Date for completing the questionnaire: *2007-08-28*

Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants

(Bio ash ID no. 4)

1. Contact

1.1 Name of plant: *Lynettefællesskabet I/S, WWTP Lynetten and WWTP Damhusåen*

1.2 Town and country: *Copenhagen, Denmark*

1.3 Contact person: *Kim Rindel*

1.4 Phone and e-mail: *+45 3268 5640. kr@lyn-is.dk*

1.5 Homepage: *www.lyn-is.dk*

2. Wastewater Treatment Plant (sum of both plants)

2.1 Load (e.g. PE_{BOD60}): *1.300.000 PE_{BOD60} and 94.000.000 m^3/year (2006)*

2.2 Main processes: *Mechanical, biological/chemical treatment, mesophilic sludge digestion.*

2.3 Precipitant for P removal: *Fe as JKL ($FeClSO_4$-solution) and aluminium as PAX-14.*

2.4 Additional comments:

3. Sludge Incineration Plant

3.1 Type of process: *Multiple hearth oven followed by electro filter and bag filter*

3.2 Amount of ashes: *6.600 t/year (2006)*

3.3 Ashes disposal/use: *Controlled land filling and various reuse (2006)*

4. Analytical data for the ashes *Average values 2006*

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
Iron as Fe_2O_3	*% w/w*	*11*	*Zinc as Zn*	*mg/kg*	*2300*
Aluminium as Al_2O_3	*% w/w*	*8*	*Copper as Cu*	*mg/kg*	*600*
Silicon as SiO_2	*% w/w*	*28*	*Lead as Pb*	*mg/kg*	*170*
Calcium as CaO	*% w/w*	*14*	*Chromium as Cr*	*mg/kg*	*50*
Phosphorus as P_2O_5	*% w/w*	*24*	*Nickel as Ni*	*mg/kg*	*40*
			Cadmium as Cd	*mg/kg*	*3*
			Mercury as Hg	*mg/kg*	*< 0,1*

Date for completing the questionnaire: *2007-08-30 by DK*

Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants
(Bio ash ID no. 5)

1. Contact

1.1 Name of plant: *WWTP Lundtofte*

1.2 Town and country: *Lyngby, Denmark*

1.3 Contact person: *Palle Jørgensen, Sabina Lind*

1.4 Phone and e-mail: *+45 4587 8691. sl@ltk.dk*

1.5 Homepage: *www.renslundtofte.dk*

2. Wastewater Treatment Plant

2.1 Load (e.g. PE_{BOD60}): *110.000* PE_{BOD60}

2.2 Main processes: *Mechanical, biological/chemical treatment, anaerobic sludge digestion*

2.3 Precipitant for P removal: *Aluminium as PAX*

2.4 Additional comments:

3. Sludge Incineration Plant

3.1 Type of process: *Fluid-bed oven followed by cyclone and bag filter*

3.2 Amount of ashes: *440 + 330 t/year (cyclone ash + bag filter ash, 2005)*

3.3 Ashes disposal/use: *In big bags to RGS90*

4. Analytical data for the ashes *Heavy metals: cyclone ash average values 2005*

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
Iron as Fe_2O_3	*% w/w*	*4,1*	*Zinc as Zn*	*mg/kg*	*1700*
Aluminium as Al_2O_3	*% w/w*	*20*	*Copper as Cu*	*mg/kg*	*600*
Silicon as SiO_2	*% w/w*	*31*	*Lead as Pb*	*mg/kg*	*130*
Calcium as CaO	*% w/w*	*14*	*Chromium as Cr*	*mg/kg*	*40*
Phosphorus as P_2O_5	*% w/w*	*18*	*Nickel as Ni*	*mg/kg*	*28*
(Data for 1 sample of			*Cadmium as Cd*	*mg/kg*	*3*
cyclone ash 020301)			*Mercury as Hg*	*mg/kg*	*< 0,1*

Date for completing the questionnaire: *2007-08-29 based upon interview by DK 2006-09-06*

Project BioCrete

Task ID: 3a
Date: 2007-09-24
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants

(Bio ash ID no. 6)

1. Contact

1.1 Name of plant: *N.V. Slibverwerking Noord-Brabant*

1.2 Town and country: *Moerdijk, Holland*

1.3 Contact person: *Leon Korving*

1.4 Phone and e-mail: *korving@snb.nl*

1.5 Homepage: *www.snb.nl*

2. Wastewater Treatment Plant

2.1 Load (e.g. PE_{BOD60}): *Approx. 4 million PE, and approx. 50 WWTP's*

2.2 Main processes:

2.3 Precipitant for P removal: *Fe as well as Al*

2.4 Additional comments:

3. Sludge Incineration Plant

3.1 Type of process: *Fluid bed incinerator (4 lines)*

3.2 Amount of ashes: *36.000 t/y*

3.3 Ashes disposal/use: *Asphalt filler (70%), German salt mine filler material (30%).*

4. Analytical data for the ashes

Average values 2004-2006 **"SiO_2 as balance"*

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
Iron as Fe_2O_3	*% w/w*	*14*	*Zinc as Zn*	*mg/kg*	*2300*
Aluminium as Al_2O_3	*% w/w*	*10*	*Copper as Cu*	*mg/kg*	*1100*
Silicon as SiO_2	*% w/w*	*26**	*Lead as Pb*	*mg/kg*	*270*
Calcium as CaO	*% w/w*	*21*	*Chromium as Cr*	*mg/kg*	*120*
Phosphorus as P_2O_5	*% w/w*	*19*	*Nickel as Ni*	*mg/kg*	*70*
			Cadmium as Cd	*mg/kg*	*4*
			Mercury as Hg	*mg/kg*	*< 0,1*

Date for completing the questionnaire: *2007-09-10 (and 2007-09-24 by DK)*

Project BioCrete

Task ID: 3a
Date: 2007-08-27
Participant: AWS
Name: DK

Questionnaire. Analytical data for ashes from European sludge incineration plants

(Bio ash ID no. 16)

1. Contact

1.1 Name of plant: *4 plants: Saint-Fons and Pierre-Benite, Petit-Quevilly and Strasbourg*

1.2 Town and country: *Lyon, Rouen and Strasbourg, France*

1.3 Contact person: *Eric Guibelin from Veolia Water / OTV*

1.4 Phone and e-mail: *+33 (0)1 7133 3196. eric.guibelin@veoliaeau.fr*

1.5 Homepage: *None. Research Program CIBSTEP 1999-2000 (reuse for concrete)*

2. Wastewater Treatment Plant

2.1 Load (e.g. PE_{BOD60}):

2.2 Main processes:

2.3 Precipitant for P removal:

2.4 Additional comments:

3. Sludge Incineration Plant

3.1 Type of process: *Fluid bed ovens built by Veolia Water (?)*

3.2 Amount of ashes: *40.000 t/year (?) as the product "Fluofill™ Le filler actif"*

3.3 Ashes disposal/use: *Concrete production and Road constructions (?)*

4. Analytical data for the ashes *Values probably from 1999*

Major components	Unit	Value	Heavy metals (optional)	Unit	Value
Iron as Fe_2O_3	*% w/w*	*4*	*Zinc as Zn*	*mg/kg*	*270-6200*
Aluminium as Al_2O_3	*% w/w*	*11*	*Copper as Cu*	*mg/kg*	
Silicon as SiO_2	*% w/w*	*38*	*Lead as Pb*	*mg/kg*	*220-680*
Calcium as CaO	*% w/w*	*20*	*Chromium as Cr*	*mg/kg*	*90-200*
Phosphorus as P_2O_5	*% w/w*	*15*	*Nickel as Ni*	*mg/kg*	
			Cadmium as Cd	*mg/kg*	*3-12*
			Mercury as Hg	*mg/kg*	*0-47*

Date for completing the questionnaire: *2007-08-30, ref. Fluofill and CIBSTEP brochures 2001*.

LIFE Project Number: LIFE05 ENV/DK/000153

Project BioCrete

Final report (date 080131)

Final report for Task 3

“White bio ash – ash production and concrete trial casting”

Appendix 2

“Calculation of cost difference between the use of Aluminium and Iron for the precipitation of phosphorus at WWTP Damhusåen”

Project BioCrete	Task ID:	3 (and 10)
	Dato:	21. Dec. 2007
	Part:	AWS
	Navn:	DK

An item in the financial report regarding the cost category "Consumables":

Calculation of cost difference between the use of Aluminium and Iron for the precipitation of phosphorus at the Wastewater Treatment Plant of Damhusåen

Estimated cost difference

According to Form F10 ("Consumable materials") in the grant agreement, the extra cost of using aluminium (Al) instead of iron (Fe) for the precipitation of phosphorus was estimated to be 26.889 €, the preconditions being:

Phosphorus precipitation using Al (as PAX-14):	Consumption 420 t	Price 182 €/t
Equivalent precipitation using Fe (as JKL):	Consumption 450 t	Price 111 €/t

The precondition that 420 t of PAX-14 is equivalent to 450 t of JKL for the process performance is based on earlier operational experiences at WWTP Damhusåen.

Actual cost difference

In the period 2006-02-09 to 2006-08-15 the dosage of JKL has been substituted by PAX-14 at WWTP Damhusåen, and according to the bills from Kemira Miljø A/S:

Phosphorus precipitation using Al (as PAX-14):	Consumption 708 t	Price 1395 kr./t
Equivalent use of JKL (708*450/420)	Consumption 758 t	Price 828 kr./t

Cost difference = 708*1395 – 758*828 = 360.000 kr. (48.000 €).

Comment

The actual cost difference is much higher than the estimated cost difference. This is mainly due to a need for a longer period of operation using PAX-14 because of a higher sludge age than expected. Also, there has been a relative increase of the price of PAX-14 compared to JKL.

Change of budget

Because of this increased cost a request for budget modification was sent to EC with the purpose to convert 'unused' equipment costs into extra costs for consumable materials. The request was accepted 2007-07-27.

LIFE Project Number: LIFE05 ENV/DK/000153

Project BioCrete

Final report (date 080131)

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Appendix 3

“Farvemåling af fliser fra BIOCRETE”

NOTAT

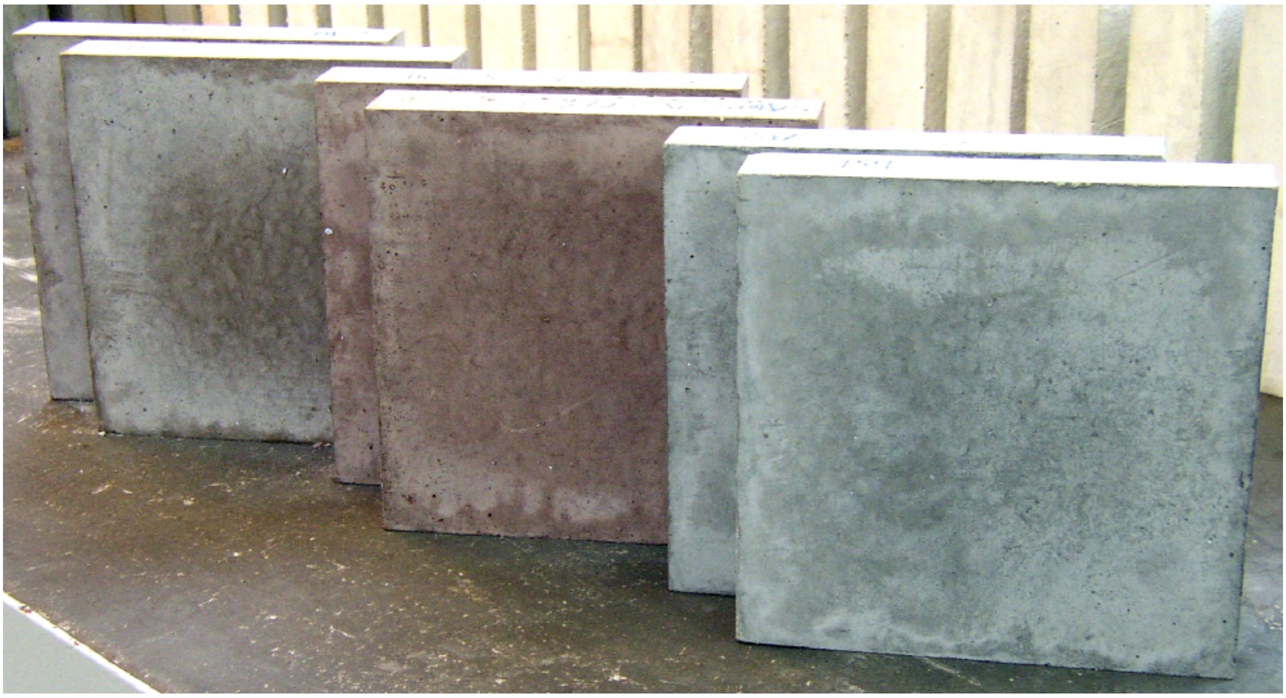
Emne: Farvemåling af fliser fra BIOCRETE, I0620004
Til: FLAR, SKK, SKL
Fra: TBH

Introduktion

Fra Teknologisk Institut er 22.06.2007 modtaget 6 stk. 30×30×5 cm fliser til farvemåling:

2 stk. mrk. **B4**
2 stk. mrk. **AWS-2 21/8**
2 stk. mrk. **AWS-3 19/6**

Figur 1 viser fliserne ved modtagelsen 22.06.2007. Fliserne er målt 29.06.2007 (efter 7 døgns standard konditionering v. 20±1°C, 55±5%RF), og igen 01.11.2007 efter opbevaring i samme klima i samlet 132 døgn (~18 uger efter første måling). Det er oplyst at farverne er set bleget over tid.



Figur 1: Fotos af fliser ved modtagelse. Fra venstre: AWS-2, AWS-3 og B4.

Konklusion

Fliserne mærket AWS-2 og AWS-3 er tydeligt mere rødlige og gullige i forhold til fliserne mærket B4. Fliserne B4 og AWS-2 har sammenlignelig reflektans, mens AWS-3 er svagt mørkere.

Der er ikke konstateret ændring af forskellen mellem de enkelte sæt fliser, hverken i reflektans eller farvetoning, ved opbevaring i laboratorieklima i 18 uger.

Resultater og diskussion

Farverne af fliserne med tilhørende 95% konfidensinterval og markering af interval for synlige ændringer er vist i Figur 2 til 4. En ændring er synlig mellem to punkter, hvis et punkt er placeret midt i markeringen og det andet netop ligger udenfor. Farvedata er vist i Tabel 1.

Af Figur 1 ses at der ikke er hverken synlig eller statistisk forskel på reflektansen af fliserne mærket B4 og AWS-2, mens fliserne mærket AWS-3 er svagt, men dog synlig mørkere (lavere L-værdi), selvom der statistisk er noget overlap med de andre fliser.

Figur 2 viser en meget tydelig forskel i rød/grøn balance. B4 fliserne er ganske svagt *grønlige* (negative a-værdier), mens AWS-2 og i særdeleshed AWS-3 er tydeligt *rødlige* (positive a-værdier).

Figur 3 viser en meget tydelig forskel i gul/blå balance mellem B4 fliserne og AWS-2 og -3 fliserne, men ikke en synlig forskel mellem AWS-2 og AWS-3. Alle fliserne er gullige (positive b-værdier).

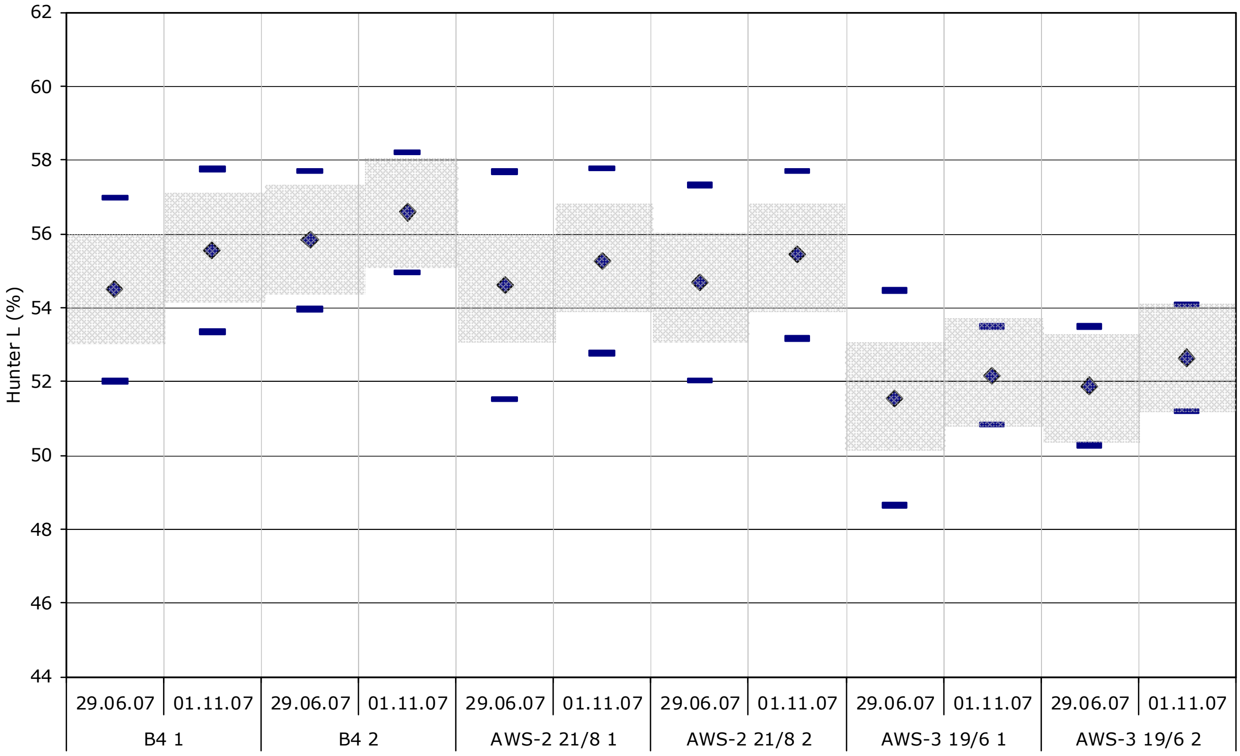
Effekten af konditionering i yderligere 18 uger er for samtlige fliser svagt lysere overflader (forskellen er ikke synlig), samt en øget farvetoning. Mest markant er en øget b-værdi (overfladen bliver mere gullig – forskellen er lige nøjagtigt af synlig størrelse).

Samlet set er fliserne mærket AWS-2 og AWS-3 altså tydeligt mere rødlige og gullige i forhold til fliserne mærket B4. Fliserne B4 og AWS-2 har sammenlignelig reflektans, mens AWS-3 er svagt mørkere.

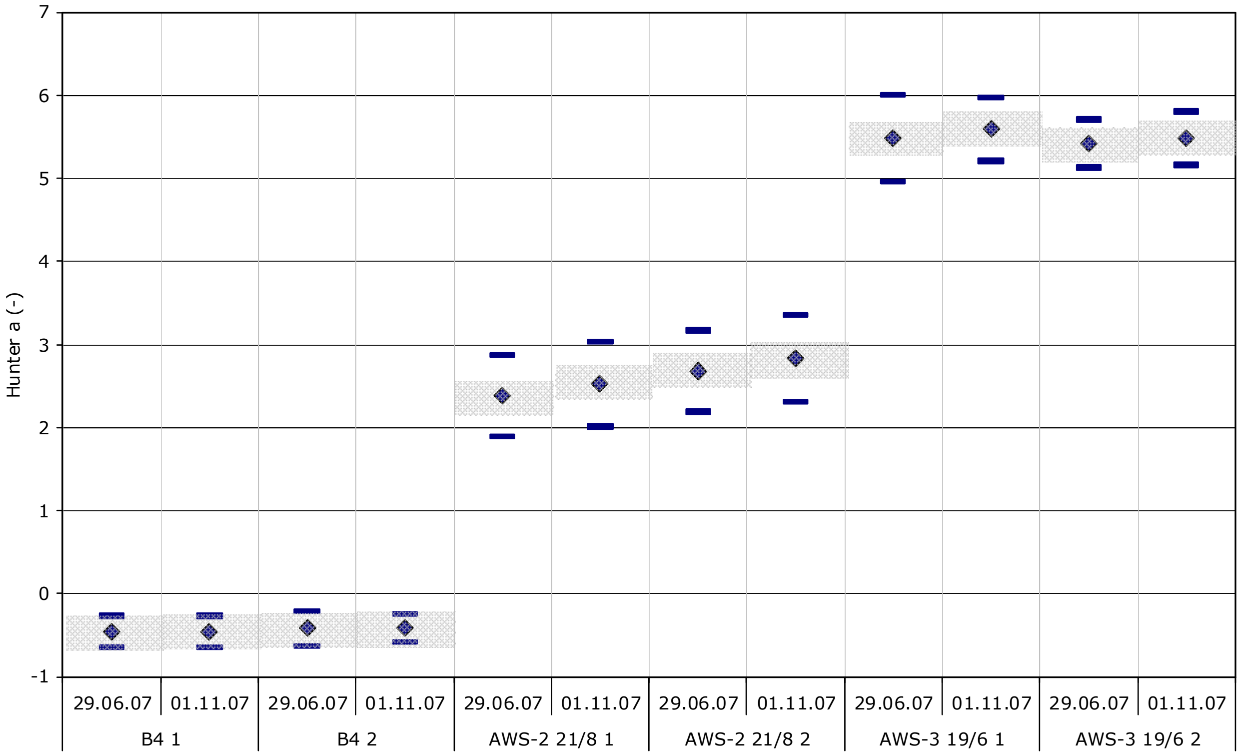
Der har ikke kunnet konstateres en ændring af forskellen mellem de enkelte sæt fliser i hverken reflektans eller farvetoning over tid, ved opbevaring i laboratorieklima.

Tabel 1: Rådata fra begge målinger.

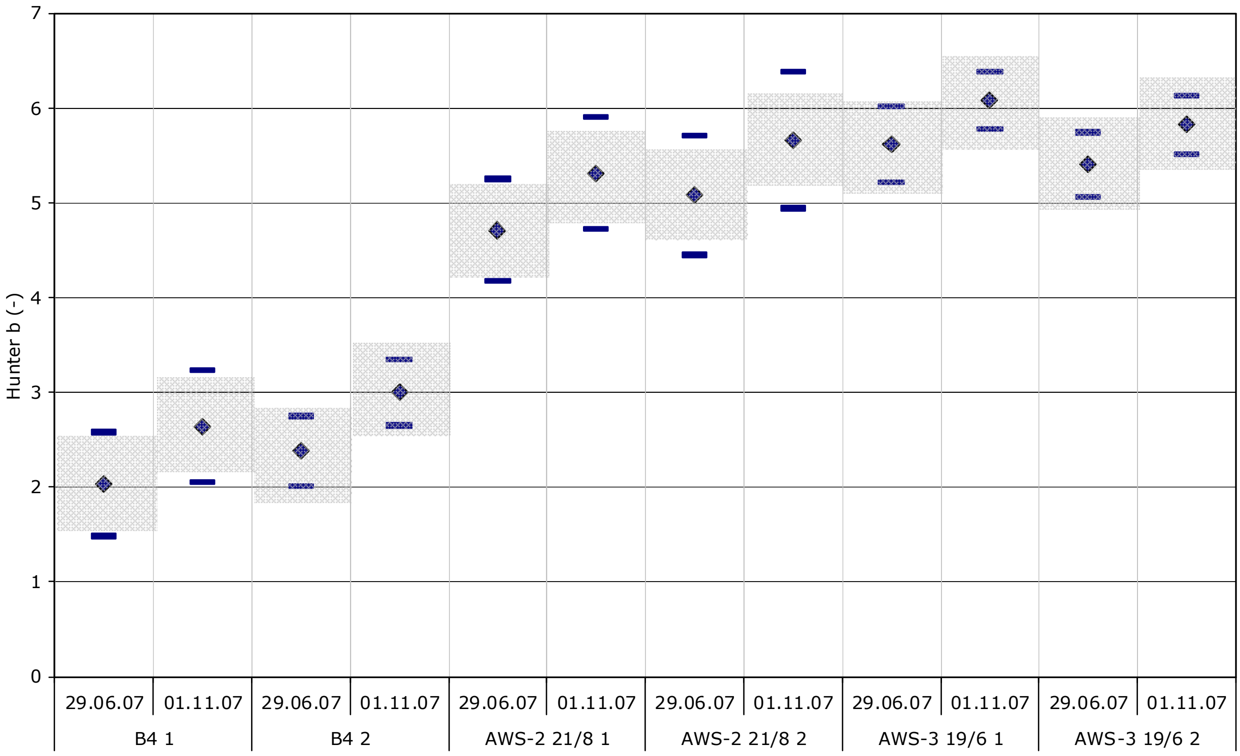
	29.06.2007						01.11.2007					
	L		a		b		L		a		b	
Emne:	Mid.	95%	Mid.	95%	Mid.	95%	Mid.	95%	Mid.	95%	Mid.	95%
B4 1	54,49	2,49	-0,46	0,19	2,03	0,55	55,55	2,20	-0,46	0,19	2,64	0,59
B4 2	55,83	1,88	-0,42	0,21	2,38	0,37	56,58	1,63	-0,41	0,17	3,00	0,35
AWS-2 21/8 1	54,60	3,08	2,38	0,49	4,71	0,54	55,26	2,50	2,52	0,51	5,31	0,59
AWS-2 21/8 2	54,67	2,65	2,68	10,49	5,08	0,63	55,43	2,27	2,83	0,52	5,66	0,72
AWS-3 19/6 1	51,55	2,91	5,48	0,52	5,62	0,40	52,16	1,33	5,59	0,38	6,08	0,30
AWS-3 19/6 1	51,88	1,61	5,42	0,29	5,40	0,34	52,64	1,44	5,48	0,32	5,82	0,31



Figur 2: Hunter L middelresultater for hver flise med 95% konfidensinterval og markering af interval for synlig ændring for hver type flise.



Figur 3: Hunter a middelresultater for hver flise med 95% konfidensinterval og markering af interval for synlig ændring for hver type flise.



Figur 4: Hunter b middelresultater for hver flise med 95% konfidensinterval og markering af interval for synlig ændring for hver type flise.

Avedøre Wastewater Services 10. January 2008. DK/dk
J.nr. UD-0350-0033. BioCrete. Task 3

Production of concrete slabs for RGB colour measurements

The slabs were casted at DTI and measured June and November 2007 at RDC, Aalborg

	Parameter	Unit	Sample ID							
			1	2	3	4	5	6	7	8
Mix design (recipe)										
	Cement(C)	kg/m^3	235	235	235					
	Fly ash	kg/m^3	70							
	Bio ash	kg/m^3		85	85					
	Water(W)	kg/m^3	180	180	180					
	Plasticizers	kg/m^3	0.8	2.1	2.4					
	Fine aggregate	kg/m^3	820	805	805					
	Coarse aggregate	kg/m^3	1024	997	997					
	W/C eq (k = 0.5 for ash)	kg/kg	0.67	0.65	0.65					
	Density	kg/m^3	2330	2304	2304					

Sample ID: (Name. Environmental class. Strength class. Bio ash origin etc.)

1 Reference concrete. P20. Fly ash "B4".

2 Light bio ash concrete. P20. Bio ash AWS 060821.

3 Red bio ash concrete. P20. Bio ash AWS 060619.