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SIMM CENTER & ABSOILS CONFERENCE - HELSINKI

ENVIRONMENTAL ASPECTS OF THE USE OF FLY ASHES AS BINDER MATERIALS FOR STABILISATION OF SOILS AND SEDIMENTS

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CONTENT

UTILISATION OF FLY ASHES BY NOTIFICATION

- Government Decree 591/2006 (Amendment 403/2009) concerning the recovery of certain wastes in earth construction:
  - Includes e. g. fly ashes from combustion of coal, peat and wood-based material
  - Defines limit values:
    - for content of harmful substances such as metals, PCB, PAH
    - for leaching of harmful substances such as metals, anions, DOC
  - Investigation done from the “fresh/untreated” fly ash from a plant
  - Limit values for leaching are defined for covered structure (>10 cm thickness of rock) and for paved structure (asphalt with max void of 5 %)
  - The decree is applied for separate layer structures of fly ashes (maximum thickness of 1,5 m)
  - Applied construction purposes: public roads, parking areas, sport grounds, industrial storage fields etc
  - Notification to a regional environment centre is needed

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UTILISATION OF FLY ASHES BY ENVIRONMENTAL PERMIT

- Utilisation of fly ashes as needs environmental permit in case:
  - Limit values are exceeded
  - The waste code of fly ash in case is not included in the decree
  - The construction purpose is other than mentioned in the decree (like private roads/ forest truck roads / noise embankments etc)
  - other applications than massive structures are not allowed such as using fly ash as binder material in mass stabilisation for soils and sediments or layer stabilisation in road construction
- Environmental permission is processed:
  - By municipal environmental authority, if the amount is < 10 000 t
  - By regional State Administrative Agencies, if the amount is > 10 000 t

CASE -PERKKAA DOG PARK PILOT IN ESPOO - UTILISATION OF SURPLUS SOILS 2012-2013

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- Area of the park 4500 m^2
- The soil of the area is clay (11…14 m) with low bearing capacity
- The purpose of the pilot was raise the area to prevent flooding by utilisation mass stabilised surplus clays in the structure
- Stabilisation properties were studied in the laboratory by compressive strength tests and by leaching tests
- Both commercial and alternative binder materials were tested; cement, lime cement, fly ashes, flue gas desulphurisation gypsum (FDG)
- Compressive strength test results showed that alternative binder materials can substitute a part of the amount of commercial binders.
- By dropping the amount of commercial binders carbon footprint of the project could be decreased

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CASE -PERKKAA DOG PARK PILOT IN ESPOO - LEACHING TESTS

- Leaching tests were carried out for clay samples stabilised with
  - Cement
  - Cement + Hanasaari fly ash (from coal combustion)
  - Lime cement + FDG
- The results indicate that the Hanasaari fly ash offers good alternative for commercial binders, as the typical leaching parameters are on low level or even lower than for commercial binders (Sb)
- For flue gas desulphurisation gypsum, chlorides leaching has to be taken into account (corrosive effect on steel structures)

CASE -PERKKAA DOG PARK PILOT IN ESPOO MODIFIED DIFFUSION TEST

Cumulative leaching of harmful substances versus surface area [mg/m^2]																	
Limit value	DOC	Chloride	Fluoride	Sulphate	Sb	As	Ba	Hg	Cd	Cr	Cu	Pb	Mo	Ni	Se	Zn	V
Permanently wet conditions [mg/m^2]		18 000	1 300	27 000	3,7	41	600	0,4	1,1	140	51	120	14	50	1,4	200	230
Occasionally wet conditions [mg/m^2]		54 000	4 400	80 000	12	140	2 000	1,4	3,8	480	170	400	48	170	4,8	670	760
Kiinteytetty materiaali** [mg/m^2]			2 800		36	58	2 800	1,6	2,1	550	250	210	70	270	14	330	700
Cement + Hanasaari Fly ash 60+100 kg/m^3																	
	<1950	1 428	208	3 045	2,3	<2	12,3	<0,2	<0,2	<2	6,1	<1	10,4	<2	<2	13,1	3,6
Lime Cement + FDG 60 + 50 kg/m^3																	
	2 420	198 590	457	9 486	14,2	<2	20,9	<0,2	<0,2	<2	17,6	<1	11,1	3,2	<2	<12	<3
Cement 80 kg/m^3																	
	2 194	1 356	219	1 614	32,6	<2	7,2	<0,2	<0,2	<2	16,1	<1	4,1	<2	<2	20,7	2,3
*Dutch limit values for solidified waste materials for earth construction (Wahlström, M, Laine-Ylijoki, J. Standardoidut liukoisuustestimenetelmät maarakentamisessa hyötykäytettävien materiaalien ympäristötestauksessa, VTT Tiedotteita 1801, 1996)																	
**Finnish guideline values for solidified waste materials for earth construction (Sorvari, J. Suomen ympäristö 421/2000)																	

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CASE -PERKKAA DOG PARK PILOT IN ESPOO - STABILISATION TESTS WITH OIL SHALE ASH

- Tested two OSA qualities are good binder materials for stabilisation of clays and sediments according to compressive strength results
- OSA B8 can be used as the *only binder component* with sediment having moderate *w* and *LoI* or combined with cement
- In stabilised, unpolluted clays *leaching of contaminants is very low* when OSA is used as binder material

CASE -PERKKAA DOG PARK PILOT IN ESPOO - LEACHING TESTS WITH OIL SHALE ASH

	OSA B8	OSA B6	Koirapuisto+ 60 kg/m^3 Cem + 100 kg/m^3 OSA B6	Koirapuisto+ 60 kg/m^3 Cem+ 100 kg/m^3 OSA B8	Koirapuisto+ 60 kg/m^3 Cem+ 50 kg/m^3 OSA B8+ 50 kg/m^3 Gyp	Limit values of Finnish regualtion 519/2006 attachment 403/2009 about the utilisation of ashes in road construction		Limit values for Finnish landfills Regulation 202/2006
	L/S=10	L/S=10	L/S=10	L/S=10	L/S=10	Covered structure[1)]	Coated structure[2)]	Conventional waste landfill
pH-start	12.8	12.7	12.0	11.7	11.4			
pH-finish	12.8	12.8	12.3	12.0	11.4			
DOC	<9.5	<11	41	45	35	500	500	800
Chloride	1600	4000	320	170	160	800	2400	15000
Fluoride	<24	<37	<8.8	4.6	<4.2	10	50	150
Sulphate	16000	16000	5.5	170	3700	1000	10000	20000
Antimony	<0.020	<0.020	<0.020	<0.020	<0.020	0.06	0.18	0.7
Arsenic	<0.020	<0.020	<0.020	<0.020	<0.020	0.5	1.5	2
Barium	3.2	4.6	0.78	0.6	0.78	20	60	100
Mercury	<0.003	<0.003	<0.003	<0.003	<0.003	0.01	0.01	0.2
Cadmium	<0.020	<0.020	<0.020	<0.020	<0.020	0.04	0.04	1
Chromium	1.1	1	0.039	0.069	0.074	0.5	3	10
Copper	<0.020	<0.020	0.12	0.11	0.092	2	6	50
Lead	<0.020	0.19	<0.020	<0.020	<0.020	0.5	1.5	10
Molybdenum	0.67	1.8	0.41	0.17	0.035	0.5	6	10
Nickel	<0.020	<0.020	0.033	0.023	<0.020	0.4	1.2	10
Selenium	0.029	<0.020	<0.020	<0.020	<0.020	0.1	0.5	0.5
Zinc	0.032	0.12	<0.020	<0.020	0.084	4	12	50
Vanadium	<0.020	<0.020	0.045	0.07	0.28	2	3	

1) Covered road means a road with at least 10 cm thick gravel (or other natural material) coating to prevent the spreading of the ash

2) Coated road means a road that is paved with asphalt or other material that provides the same kind of protection for the structure

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CASE – WEST HARBOUR IN HELSINKI – JÄTKÄSAARI III 2014

- Dredged sediments are disposed to stabilisation pools, mixed with binders by mass stabilisation and then transported to final utilisation sites
- Stabilisation properties were studied in the laboratory by compressive strength tests before the launch of the mass stabilisation in the pools
- Technically most promising binder combinations were studied by leaching tests as well
- Following different binder mixtures were tested:
  - Cement + Hanasaari Fly ash
  - Cement + Hanasaari Fly ash +FDG
  - Lime cement + Hanasaari Fly ash
  - Lime cement + Hanasaari Fly ash + FDG
  - Oil shale ash

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CASE – WEST HARBOUR IN HELSINKI – JÄTKÄSAARI III 2014

- The results indicate that the mixture of cement/lime cement +Hanasaari fly ash offers good alternative, as the leaching of harmful substances are lower than the suggested limit values for utilisation of masses in noise embankment structure
- Flue gas desulphurisation gypsum increases leaching of chlorides which has to be taken into account, when the utilisation site is considered
- For oil shale ash, the leaching of harmful substances are on the same level as for other samples

CASE – WEST HARBOUR IN HELSINKI – JÄTKÄSAARI III 2014

Cumulative leaching of harmful substances versus surface area [mg/m2]																		
	Chloride	Sulphate	Fluoride	Sb	As	Ba	Hg	Cd	Co	Cr	Cu	Pb	Mo	Ni	Se	Zn	V	Sn
Suggested limit values* [mg/m^2]	162500 (16250)	162500 (97500)	2 800	36	58	2 800	1,6	2,1	280	550	250	210	70	270	14	330	700	280
Cement + Hanasaari fly ash 50+150 kg/m3																		
	45 982	842	*106*	6,0	*0,4*	3,8	*0,04*	*0,04*	*0,21*	*0,4*	0,7	*0,2*	15,2	0,4	0,7	*2,4*	2,7	4,30
Cement + Hanasaari fly ash + FDG 50+75+75 kg/m3																		
	104 454	1 150	*122*	8,5	*0,5*	5,8	*0,05*	*0,05*	*0,25*	*0,5*	1,1	*0,3*	18	0,5	0,9	*3,0*	0,7	1,5
Lime cement + Hanasaari fly ash 50+150 kg/m3																		
	46 313	1 061	*117*	16,8	*0,5*	3,6	*0,05*	*0,05*	*0,25*	*0,5*	1,0	*0,3*	15,8	0,7	0,6	*4,0*	2,3	6,45
Lime cement + Hanasaari fly ash + FDG 50+75+75 kg/m3																		
	106 855	738	*124*	13,7	*0,5*	9,3	*0,05*	*0,05*	*0,25*	*0,5*	2,1	*0,3*	11	2,7	0,7	*2,9*	1,4	*1,9*
Oil shale ash 150 kg/m3																		
	82 972	2 230	*117*	14,7	*0,5*	4,3	*0,05*	*0,05*	*0,25*	*0,5*	3,3	*0,3*	3,6	1,5	*0,5*	*3,5*	1,6	1,86
* Suggested limit values in environmental permit application for noise embankment structure																		

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CASE – THE PORT OF KOKKOLA IN FINLAND

STABILISATION OF DREDGED SEDIMENTS DURING SMOCS PROJECT

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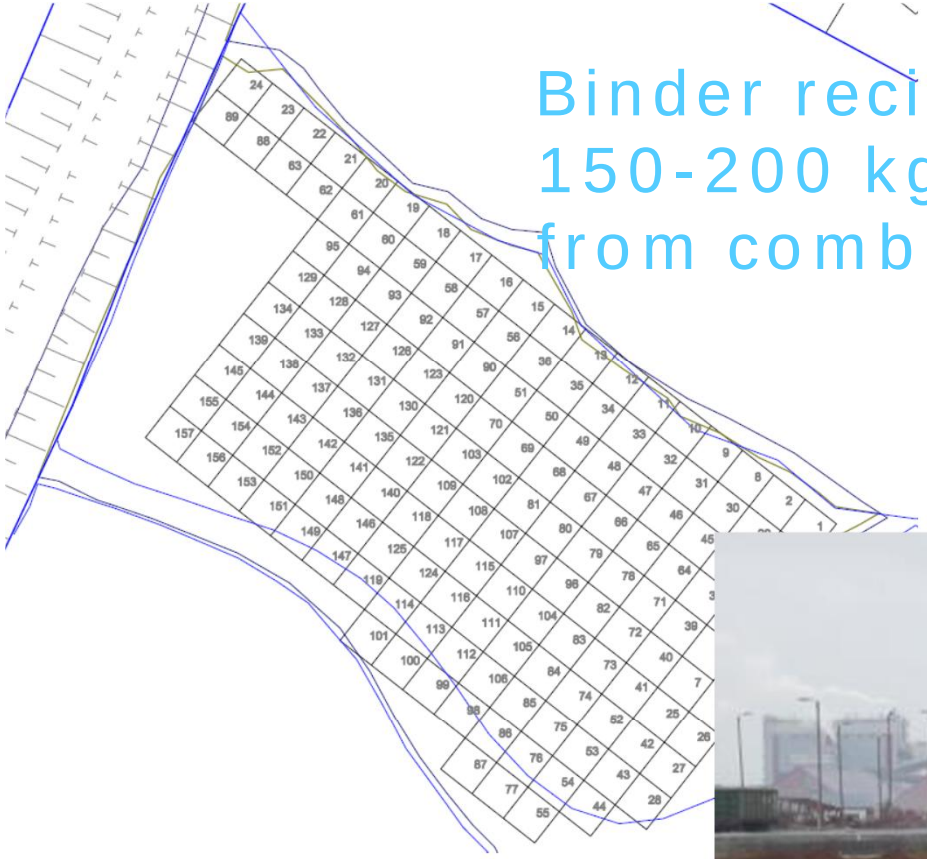

Binder recipe:
150-200 kg/m³ Fly ash
from combustion of peat, wood, REF

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CASE PORT OF KOKKOLA – LEACHING TEST RESULTS FOR STABILISED CONTAMINATED SEDIMENTS

Sample code	Added binders [kg/m3]		Reference values for contaminated soil*	Zn tot [mg/kg]	Cd tot [mg/kg]	Acceptance criteria for landfills***	Zn L/S 10 [mg/kg]	Cd L/S 10 [mg/kg]
			Threshold value	200	1			
			Lower guideline value	250	10	Inert waste	4	0,04
			Higher guideline value	400	20	Regular inorganic + treated hazardous waste	50	1
			Hazardous waste limit value**	2500	1000	Hazardous waste	200	5
KS201, aged sample	-	-		3 300	16		41,95	<
KS201, aged sample	Ce	50					0,12	<
KS201, aged sample	Ce+BFS	50+100					0,24	<
KS201, aged sample	Ce+FA	50+100					0,01	<
KS201, aged sample	Ce+DI	50+100					0,16	<
KS201, aged sample	Ce+BFS+FA	50+100+100					0,01	<
KS201, aged sample	Ce+BFS+DI	50+100+100					<	<
KS201, aged sample	Ce+FA+DI	50+100+100					0,13	<
KS201, aged sample	Ce+BFS+FA+DI	50+100+100+100					<	<
KS201, aged sample	Ce+BFS+FA+DI	50+50+50+50					0,48	<
KS201, aged sample	Ce+BFS+FA+DI	50+50+50+50					<	<
KS201, aged sample	Ce+BFS+FA+DI	50+50+50+50					<	<

* Finnish Govermanet Decree on the Assessment of Soil Contamination and the Remediation Need (214/2007)

** Hazardous waste limit values applied in Finland

*** The Amendment of Government Decision on Landfills 202/2006 in Finland

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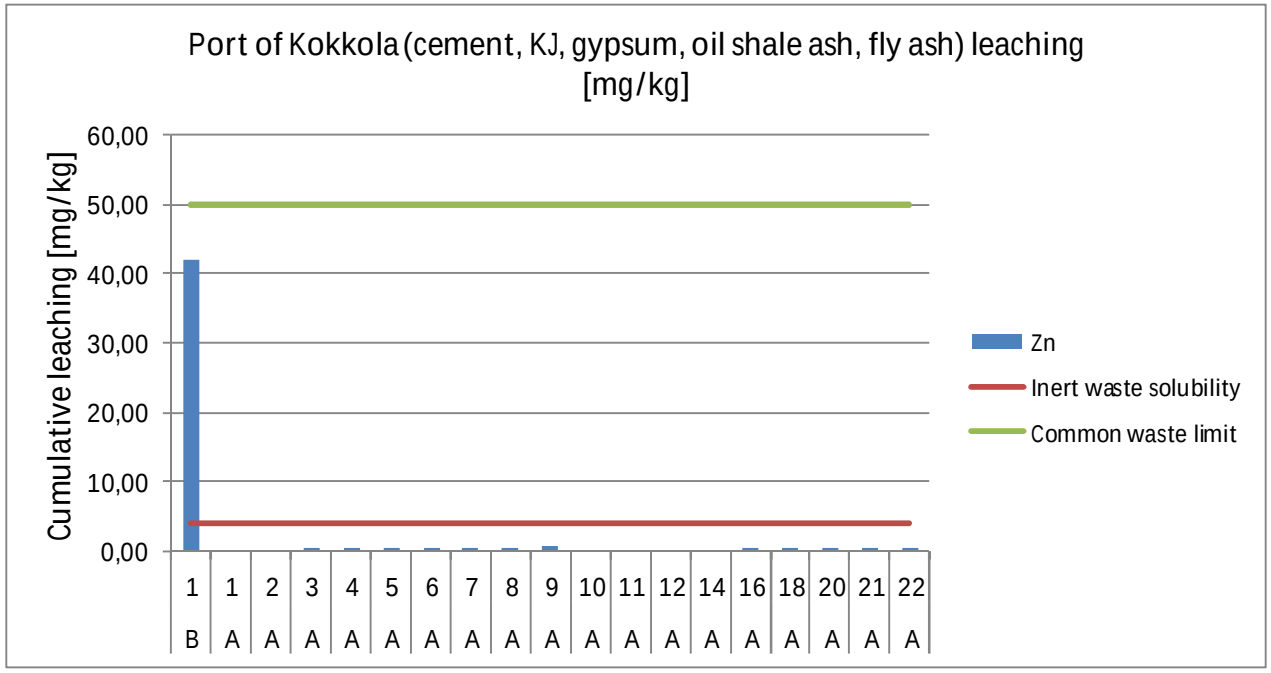
Ce = cement; BFS = blast furnace slag; FA = fly ash; DI = gypsum

CASE PORT OF KOKKOLA – LEACHING OF ZINC IN STABILISED SEDIMENT



2-stage batch test: untreated sediment sample; stabilised sediment samples

Ce = cement; BFS = blast furnace slag; FA = fly ash; DI = gypsum

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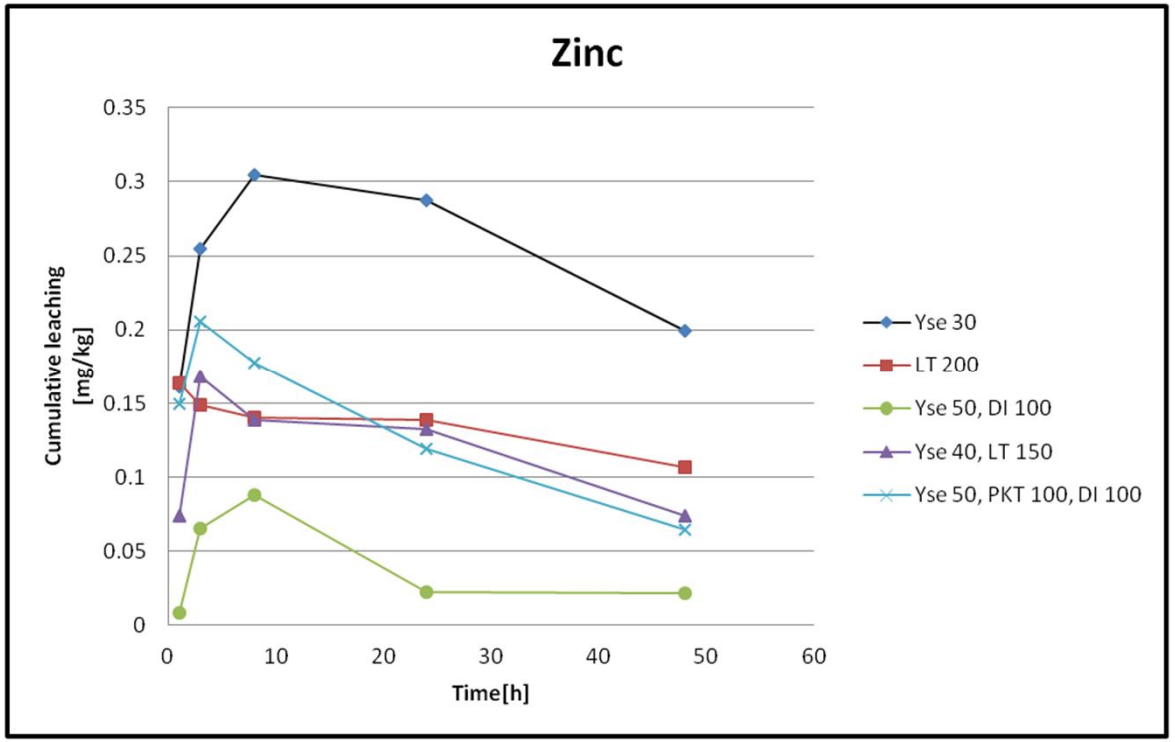
CASE PORT OF KOKKOLA
LEACHING OF ZINC AS A FUNCTION OF TIME IN MODIFIED BATCH TEST



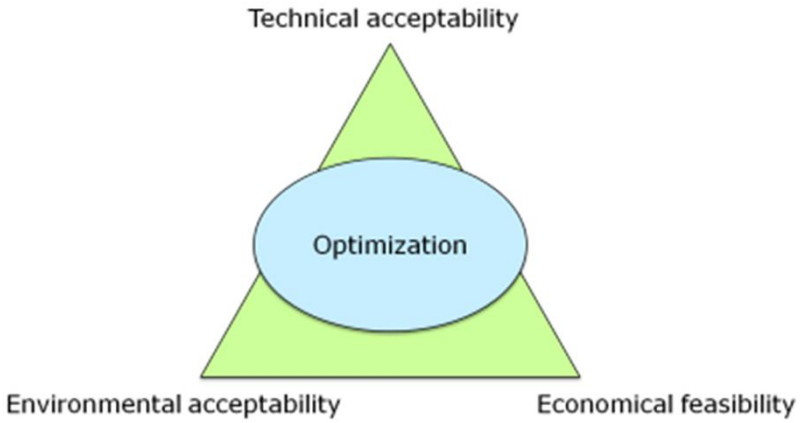
There are differences between binders during the first 10 hours of the test, but after that the differences start to reduce and the leaching of zinc continues to decrease (total content of the zinc in the sediment sample is 560 mg/kg)

CASE PORT OF KOKKOLA – SOME CONCLUSIONS OF LEACHING

- High total content of zinc in the sediment, above hazardous waste limit value
- Leaching of zinc in the untreated sediment above inert waste limit value for leaching
- Leaching of zinc is very low for stabilised sediment, below detection limit or below inert waste limit value
- Zinc is probably bound chemically to the matrix after it was not released from crushed sample in the batch test
- Bioavailability of zinc is low in stabilised matrix
- Combining two waste materials (contaminated sediment and fly ash), can form a environmentally safe material for earth construction purposes

SOME FINAL REMARKS

- Utilisation of industrial by-products have many benefits in stabilisation of surplus soils or contaminated sediments:
  - Technically and environmentally acceptable solutions
  - Savings in binder costs
  - By dropping the amount of commercial binders carbon footprint of the project can be decreased



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THANK YOU!

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