

Centre of Environmental Research

Waste Management,
Circular Economy and
Environmental Security

WP1.A.2 Reducing the amount of
hazardous substances in building and
construction materials

Environment - Environment for Life
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Reduction of the environmental burden of wastes by their utilization in building materials

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A wide range of selected wastes (BP) for use



Ashes

- **Fly ash**
Ledvice, Prunéřov, Tušimice, Počerady, Tisová, Chvaletice, Dětmarovice, Mělník, Opatovice, Arcelormittal power plants.
- **Slag**
Tušimice, Mělník, Oslavany power plants
- **FBC ashes**
Ledvice, Tisová, Poříčí, Třinec, Hodonín, Kladno power plants
- **Bed ashes**
Ledvice, Tisová power plants
- **Slag from municipal waste incinerator plant**
SAKO
- **END product from municipal waste incinerator**
SAKO
- **Desulfurization products**
SDA of Trmice, energo-gypsum from Opatovice power plant

Hazardous waste

- **Solid wastes from waste gas treatment**
filter ash from the incineration of hazardous waste from the healthcare sector
- **Ash and slag containing hazardous substances**
slag from the incineration of hazardous waste from the healthcare sector
- **Acid pickling solutions**
an acidic solution with a high content of dissolved substances, mainly Fe^{2+}
- **Sludge from other industrial wastewater treatment methods containing hazardous substances**
sludge from the production of technical rubber
- **Sludge from the biological treatment of industrial wastewater containing hazardous substances**
- **Sludges from physico-chemical processing containing hazardous substances**
produced as a by-product during the plating process of steel materials

Possibilities of use in classic building materials

- Replacement of natural aggregate
 - Aggregate for concrete
 - Aggregates for mortars
 - Aggregate for cemented/non-cemented mixtures
 - Filled dams
 - Porous aggregates
- Active ingredients for cement composites
- Raw materials for cement production
- Lime
- Plaster and plaster-based products
- Aerated concrete
- Raw materials for the preparation of ceramics

Selected waste utilization options

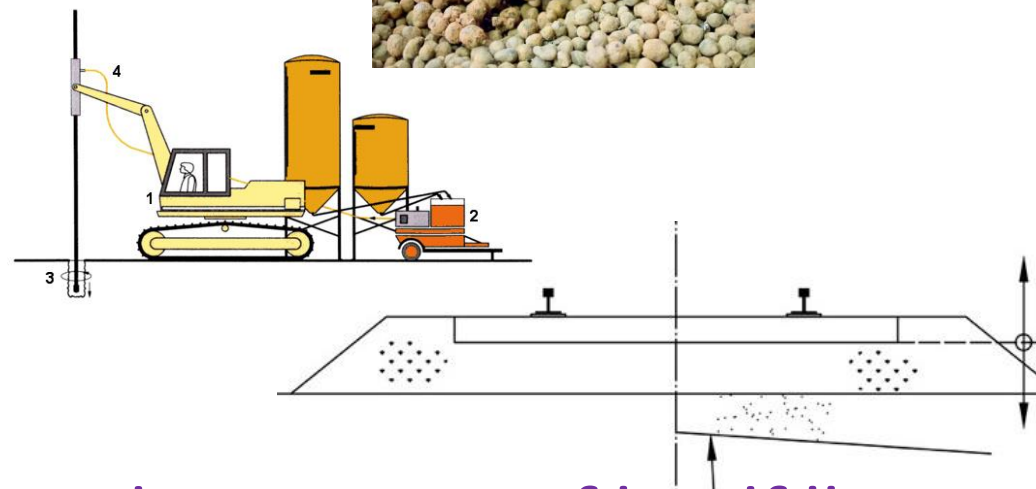
- **Artificial aggregates (sintered, non-sintered)**

- Mixtures of ash + fuel/binder (+ additives)



- **Injection of bulk dams**

- Mixtures of fly ash + clay + binders (+ additives)



- **Bonded layers**

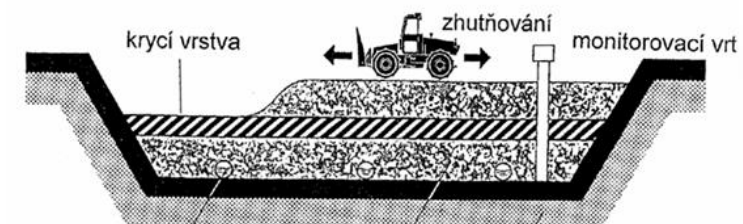
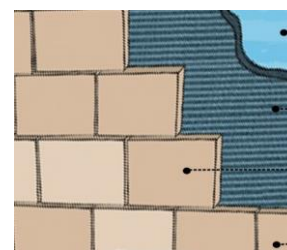
- Wastes (+ binders) (+ soil)

- **Solidifieds from HW for reclamation and treatment of landfills**

- Sludges (solutions) + solidifying agents (binders + admixtures/additives)

- **Polymer materials**

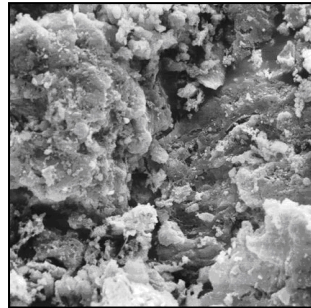
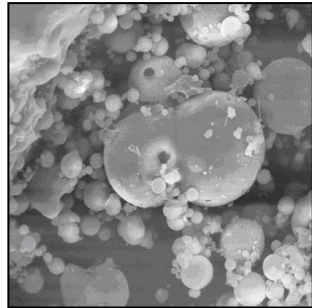
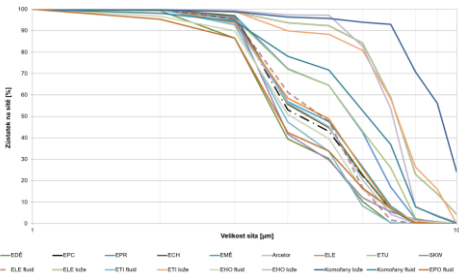
- Polymer base + ash (HW, solids)



Utilization of fly ash in artificial aggregates



Analyzes of different types of fly ash



• Fly ash

- high SiO_2 ,
- influence on environment – mainly heavy metals
- suitable replacement for cement, fillers, sintered aggregate

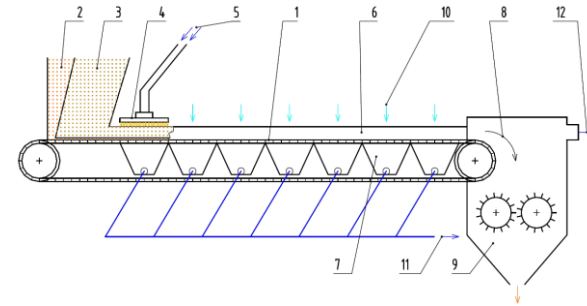
• FBC ash

- Higher content of CaSO_4 , CaO etc.,
- influence on environment – mainly především sulfates and solutes
- vhodná náhrada vápna, kamenivo nespékané

• Coarse ashes

- without embankment/backfill treatment
- after grinding, the potential for the same use as fine

Verification of fly ash for artificial aggregates



• Fly ash

- ideal for sintered aggregates
- can also be unsintered with cement
- reduction of heavy metals below limits by firing

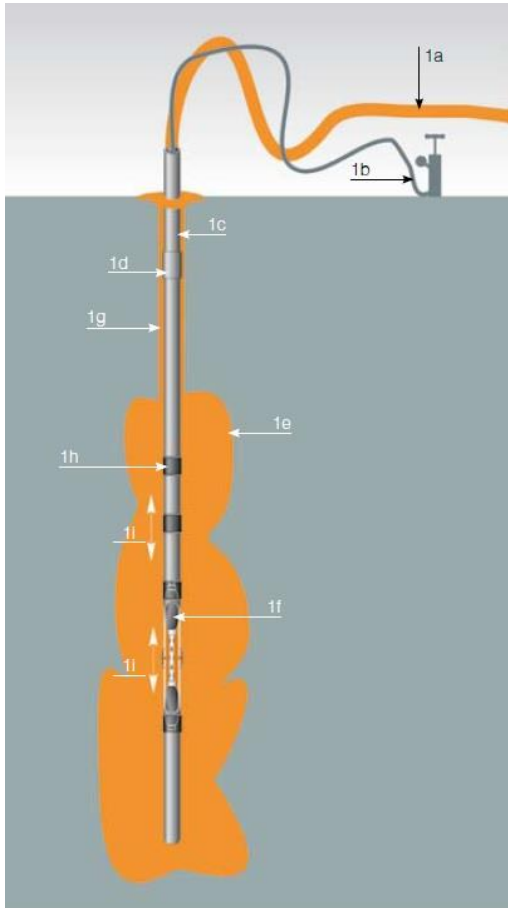
• FBC ash

- not suitable for sintered aggregates (low strength, high absorbency)
- only for unsintered, it is also possible without binders
- after curing, sulfates and dissolved substances fall safely below the limits

• Coarse ashes

- unsuitable for aggregates without modification

Utilization of fly ash for dam injection



Exploration



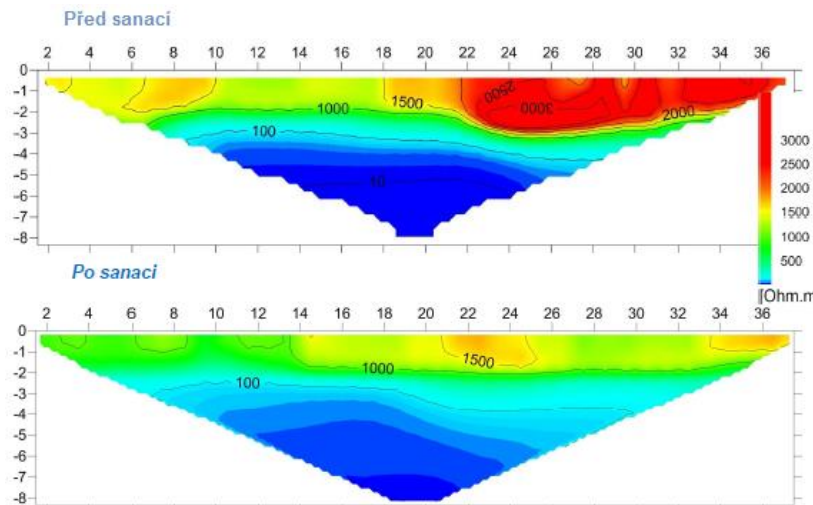
Drilling



Adjusting of drill holes



Injection



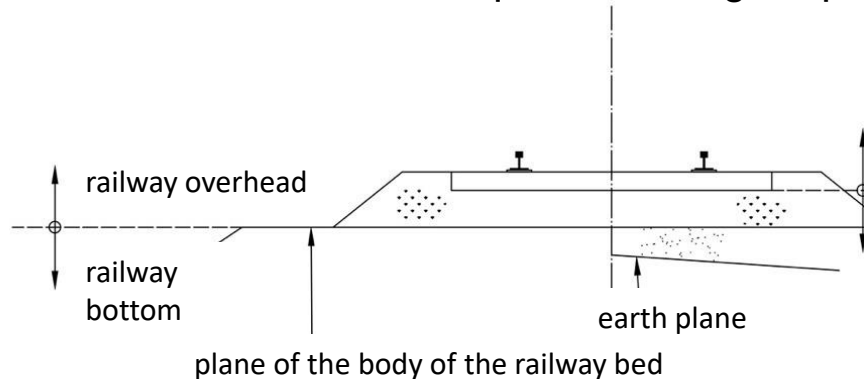
Successful remediation via injection

Optimal mixture:

- 25% Fly ash
- 75% clay Ge – montmorillonite-illite clay
- 4% cement
- Optimal combination of strength, stability and sealing function
- The impact on the railway is safely within limits

Bonded layers

- Reducing the environmental burden from waste disposal,
- increasing their resistance and durability,
- reduction of material requirements of construction and reconstruction,
- development and verification of unique technological procedures.



Suitable waste for use (mechanically and ecologically):

- Recycled concrete,
- waste from track bed cleaning,
- slag from the municipal waste incinerator plant,
- FBC ash from burning coal and biomass.



Concrete

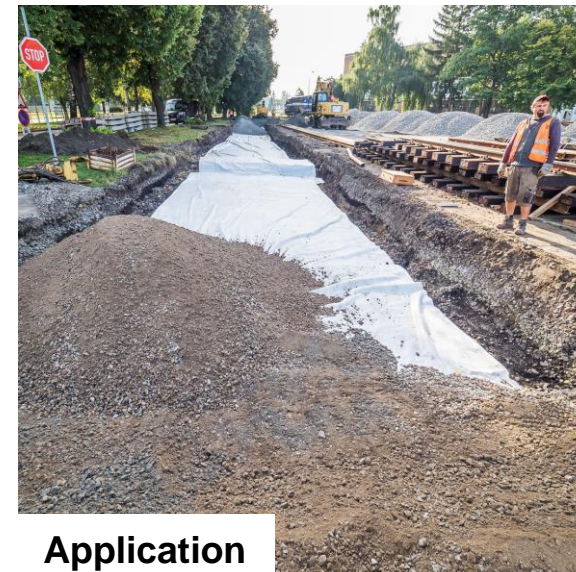
Brick

Asphalt

Waste from track bed cleaning



Slug from municipal incinerator plant



Application



After execution

Solidification of waste - landfill reclamation



BOHUMÍN

pH (25°C)	12
Dissolved substances (DS) [mg/l]	3910
Chlorides [mg/l]	1430
Sulphates [mg/l]	80

Dry matter [%]	42,89
Chrome [mg/kg]	159
Nickel [mg/kg]	77,8
Lead [mg/kg]	1870

Optimal future application of solidificate

1. Reinforced backfill material
2. Un-reinforced backfill material
3. Remediation of ecological burdens



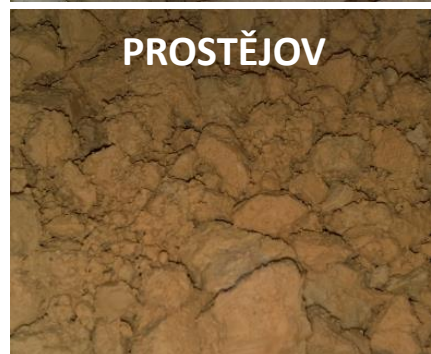
OSTRAVA

pH (25°C)	8,9
Dissolved substances (DS) [mg/l]	3480
Chlorides [mg/l]	458
Sulphates [mg/l]	1960

Dry matter [%]	44,11
Chrome [mg/kg]	574
Nickel [mg/kg]	55,2
Lead [mg/kg]	240

Optimal methodology of solidificate testing

1. Demands on environmental and health protection
2. Physically-mechanical and technology demands



PROSTĚJOV

pH (25°C)	9,9
Dissolved substances (DS) [mg/l]	2810
Chlorides [mg/l]	935
Sulphates [mg/l]	221

Dry matter [%]	24,19
Cadmium [mg/kg]	146
Chrome [mg/kg]	3990
Nickel [mg/kg]	30,5
Lead [mg/kg]	108
C10 - C40 [mg/kg]	949

Solidification of waste - landfill reclamation

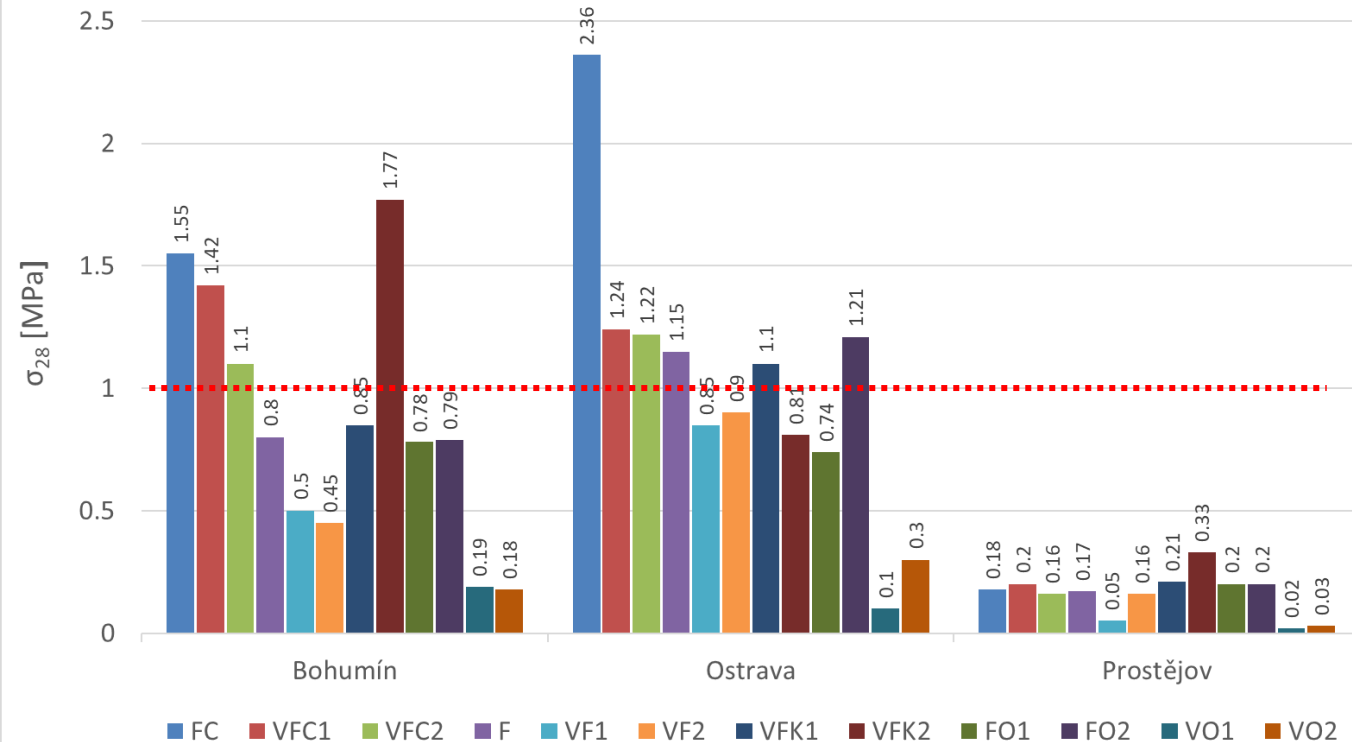


Used solidification agents (binders and additives)

- Fly ash Chvaletice (CA_{CHVAL})
- FBC ash Hodonín (FA_{HOD})
- Carbide lime
- Slag from the ladle furnace - ArcelorMittal, a.s.
- Cement CEM II/B-M (S-LL) 32,5 R Mokrý

Mixture	FC	VFC1	VFC2	F	VF1	VF2	VFK1	VFK2	FO1	FO2	VO1	VO2
	1	2	3	4	5	6	7	8	9	10	11	12
CA_{CHVAL}	-	10	20	-	10	20	15	5	-	-	40	30
FA_{HOD}	45	35	25	50	40	30	25	25	40	30	-	-
ODPR.	-	-	-	-	-	-	-	-	10	20	10	20
NK	50	50	50	50	50	50	50	50	50	50	50	50
CARB.L.	-	-	-	-	-	-	10	20	-	-	-	-
CEM	5	5	5	-	-	-	-	-	-	-	-	-
WATER [%]	26 – 32						18	12	28-32		20 – 24	

Pevnost v tlaku krychelná- 28d



The mixtures met the environmental limits

The mixtures also met the strength limits

Selected neutralization sludge	BOHUMÍN	OSTRAVA	
Properties/Mixture designation	VFC2	VFC2	VFK1
Loss on drying [%]	-	8,84	14,28
pH (25°C)	-	9,8	10,0
El. conductivity [mS/m]	496	272	259
Dissolved substances [mg/l]	2890	2670	2530
Compressive strength 28d [MPa]	1,1	1,2	1,1
Volumetric weight 28d [kg/m ³]	990	1000	980

Utilization of HW in polymer materials

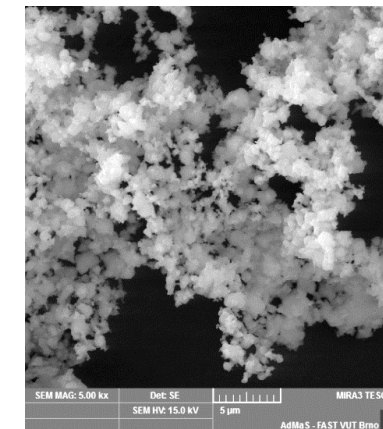


Selected formulas and HW – coating, jointing and rehabilitation materials

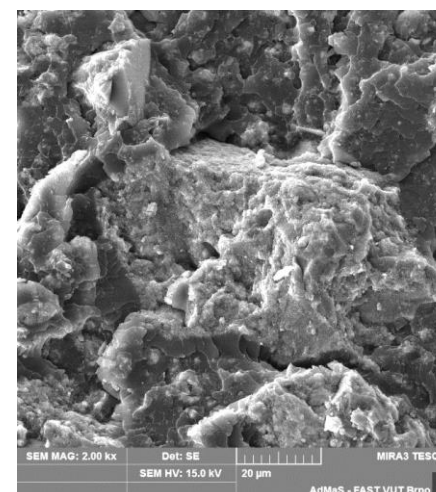
- HW – Bohumín neutralization sludge, bypass dust from the cement plant
- Polymer matrix – Epoxy resin, Polyurethane resin
- Solidifying agents – FBC ash, quartz powder



Dried and ground neutralization sludge Bohumín



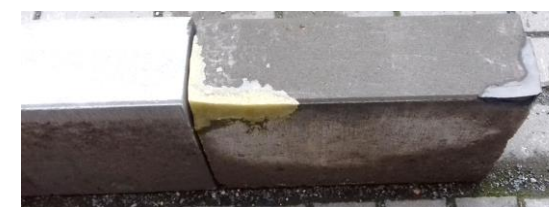
Bypass dust from the cement plant



HW particle embedded in the epoxy matrix of the coating



Coating System Layer (N3)

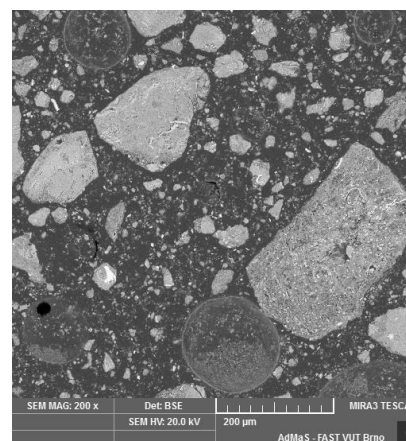


Curb repaired with SA1 compound

Mixture designation	N1	N2	N3	N4	SP1	SP2	SA1	SA2
Cement dust	-	15	-	15	15	-	40	-
HW	15	-	15	-	-	15	-	40
Quartz powder	6	6	6	6	10	10	-	-
FBC ash	9	9	9	9	15	15	-	-
PUR	-	-	70	70	-	-	-	-
EP	70	70	-	-	60	60	60	60



Jointing of basalt tiles using SP1 mixture



Incorporation of NK (HW) particles in epoxy matrix SA2

Examples of execution



Injection of bulk dams of ponds



Soil stabilization



Remediation of the NO landfill using solidified



Injection of the bulk dam of the water reservoir



Application of solidified - the base layer of the road