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A 3. Material matrix for mining operations

Material		Tested in laboratory	Tested in field	Material technical suitability for different structure types			Material environmental suitability for different structure types			Comments
				Cover structure	Bottom structure	Reactive barrier	Cover structure	Bottom structure	Reactive barrier	
Fibre clays	KJ M (Fiber clay 1)	x	x	++	+	-	++	++	+	4 different fibre clay has been tested in laboratory for cover and bottom structures and reactive barriers. The suitability for cover structures has been verified in field tests (3 different type) and it is suitable for cover structures. The low permeability tested in laboratory enables also the use in bottom structures. The achievable permeability depends on the material properties (e.g. density, level of compaction and water content. Water permeability < 1 x 10-8 m/s was achieved with all tested materials but lower requirements can be difficult to achieve. Low waterpermeability can be problematic for reactive barriers as the water flow throuhg the material is slow. The material properties varies between different factories therefore the material tests are essential before use.
	KJ N (Fiber clay 2)	x	x	++	+	-	++	++	+	
	KJ E (Fiber clay 3)	x	x	++	+	-	++	++	+	
	KJ F (Fibre clay 4)	x		++	+	-	++	++	+	
Dry fly ashes	LT C (Biomass & peat fly ash)	x	x	++	-/+	+	+	+	0	Various fly ash grades was tested for cover structure purposes. Fly ash was tested alone as well as mixed with enrichment sand and moraine. The k-values for all tested fly ash mixtures were above 10^{-8} m/s, which may preven the use of material in bottom structures where typical requirements are 10^{-8} - 10^{-9} m/s. The alkaline fly ash can function as neutralizer for acid mine drainage if used in cover layers or reactive barriers and it can precipitate many metals. The environmental properties and possible joint effects needs to be studied case by case as leachability of certain heavy metals can increase with some fly ashes. In addition, the technical suitability needs to be studied case by case as there were a lot of variety in the results with differend fly ash grades.
	LT I (Biomass & peat fly ash)	x		+	-/+	+	0	0	0	
	LT A (Biomass & REF fly ash)	x		++	-/+	+	-/+	-/+	-/+	
	LT H (Biomass & peat fly ash)	x		++	-/+	+	+	+	0	
	LT D (Biomass & REF fly ash)	x		++	-/+	+	0	0	0	
	LT B (Biomass & Peat fly ash)	x		++	-/+	+	+	+	0	
Piled fly ashes	KT C (Biomass & peat piled fly ash)	x		-/+	-/+	-/+	0	0	0	Piled fly ashes were in general less reactive than dry fly ashes. Therefore the technical suitability depends on the application and possible material mixture and it needs to be verified case by case. The leaching of inorganic components from pile stored fly ashes usually decreases over time which increases the environmental suitability.
	KT I (Biomass & peat piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT A (Biomass & REF piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT D (Biomass & REF piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT B (Biomass & Peat piled fly ash)	x		-/+	-/+	-/+	0	0	0	
	KT J (Biomass piled fly ash)	x		-/+	-/+	-/+	0	0	0	
Foundry sands	Foundry dust 1 (Bentonite sand process)	x		+	+	0	-	-	-	Tested foundry sands contained bentonite. Mixing of foundry sands (10%) with moraine it was possible to achieve lower water permeability compared to moraine itself. Achieved permeability values of moraine-foundry sand mixtures varied in laboratory tests between 5,4 x 10^{-9} m/s - 2,0 x 10^{-10} m/s. The environmental suitability of foundry sand varies between different foundries and it needs to be verified case by case.
	Foundry sand 1 (Bentonite sand process)	x		+	+	0	-/+	-/+	0	
	Foundry sand 2 (Bentonite sand process)	x		+	+	0	-/+	-/+	0	
Gypsum	Gypsum waste (phosphogypsum)	x	x	+	0	0	+	+	0	Tested gypsum waste was found out to be suitable for cover structures. The k-value for material itself is relatively high (10^{-3} - 10^{-4} m/s), which needs to take into account in design.
Lime	Lime waste (2nd grade burnt lime)	x		+	+	+	+	+	+	Lime waste was found out to be suitable material, usually mixed with other materials, for all tested applications.

Abbreviations e.g. LT A refers to materials in deliverable "A3. Final techical report"

-	Not suitable
0	Not tested

-/+	Uncertain
+	Suitable with some exceptions
++	Suitable