



SLOVENSKI STANDARD
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Zemeljska dela - 8. del: Alternativni materiali pri zemeljskih delih

Earthworks - Part 8: Alternative materials in earthworks

Erdarbeiten - Teil 8: Alternative Materialien für Erdarbeiten

Terrassements - Partie 8 : Matériaux alternatifs pour les terrassements

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Erdarbeiten - Teil 8: Alternative Materialien für
Erdarbeiten

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European foreword

This document (CEN/TR 16907-8:2024) has been prepared by Technical Committee CEN/TC 396 “Earthworks”, the secretariat of which is held by AFNOR.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document complements the European Standards within the framework series of EN 16907 on Earthworks:

- EN 16907-1, *Earthworks — Part 1: Principles and general rules*;
- EN 16907-2, *Earthworks — Part 2: Classification of materials*;
- EN 16907-3, *Earthworks — Part 3: Construction procedures*;
- EN 16907-4, *Earthworks — Part 4: Soil treatment with lime and/or hydraulic binders*;
- EN 16907-5, *Earthworks — Part 5: Quality control*;
- EN 16907-6, *Earthworks — Part 6: Land reclamation earthworks using dredged hydraulic fill*;
- EN 16907-7, *Earthworks — Part 7: Hydraulic placement of waste*;
- CEN/TR 16907-8, *Earthworks — Part 8: Alternative materials in earthworks* (this document);
- CEN/TR 16907-9, *Earthworks — Part 9: Sustainable earthworks* (Under preparation).

These “Earthworks standards” do not apply to the environmental planning and geotechnical design that determines the required form and properties of the earth-structure that is to be constructed. They apply to the design of the earthwork's materials, execution, monitoring and checking of earthworks construction processes to ensure that the completed earth-structure satisfies the geotechnical design.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

1 Scope

This document informs about the experience of European member state practices for successfully using alternative materials in earthworks. It covers all earthworks, whether for roads, railways, and other infrastructure, including fills, capping layers, transition zones, drainage ribs or others (for details, see EN 16907-1:2018, Clause 1 “Scope”).

Alternative materials have properties, on a geotechnical standpoint, which makes them different from the materials (soils and rocks) being normally used in earthworks. Therefore, the objective of this document is:

- to give an overview of the alternative materials that have been successfully used in earthworks in Europe;
- for the alternative materials, for which use in earthworks is adequately documented, to give general information regarding the points of attention that clients, designers and earthwork companies, keep in mind in any attempt to use them in earthworks.

This document does not deal with alternative materials used as aggregate.

This document does not deal with alternative materials used as binders (fly ash, granulated blast furnace slag or others) or binder components.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp/>

4 Abbreviations

ABS	air-cooled blast furnace slag
ASAM	<i>Asociace stavebních alternativních materiálů</i> (Association of construction alternative materials in Czechia)
BOS	basic oxygen furnace slag
CBR	California Bearing Ratio
CCP	coal combustion products
CO ₂	carbon dioxide
CSH	calcium silicate hydrates
ECOBA	European Coal Combustion Products Association
EAF S	electric arc furnace slag from stainless/high alloy steel production

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EAFC	electric arc furnace slag from carbon steel production
EPB	earth pressure balance
FBC	fluidized bed combustion
FBCFA	fluidized bed combustion fly ash
FGD	flue gas desulphurisation
GBS	granulated blast furnace slag
LA	Los Angeles coefficient (see EN 1097-2)
LOI	loss on ignition
MDD	maximum dry density (see EN 13286-2)
MIBA	municipal incinerator bottom ash
MIFA	municipal incinerator fly ash
OMC	optimum moisture content (see EN 13286-2)
PAH	polyaromatic hydrocarbons
PFA	pulverized fuel ash
pH	decimal logarithm of the reciprocal of the hydrogen ion activity
SMS	secondary metallurgical slags
SNCR	selective non-catalytic reduction (method of denitrification)
TBM	tunnel boring machine
UIC	International Union of Railways (<i>Union internationale des chemins de fer</i> - French)
UKQAA	UK Quality Ash Association
UPS	<i>Polska Unia Ubocznych Produktów Spalania</i> (Polish Association of Coal Combustion Products)
WG7	working group 7 “Alternative materials in earthworks” of CEN/TC 396 “Earthworks”

5 Alternative materials definitions

Alternative materials are considered as anthropogenic materials according to EN 16907-2. In Table 1, groups of alternative materials are grouped according to the Table 5 of EN 16907-2:2018.

Table 1 — The groups of alternative materials by groups in EN 16907-2

Group	Source	EN 16907-2
A	Construction and demolition recycling industries	AR
B	Municipal solid waste incineration industry	AM
C	Coal Power generation industry	AM
D	Iron and steel Industry	AM
E	Non-ferrous industry	AM
F	Foundry industry	AM
G	Mining and quarry industry	AN (AM)
H	Excavated natural materials	AN
I	Other combustion residues	AM
J	Miscellaneous	AM (AR)
Key AN – natural materials processed mechanically; AM – manufactured materials (including secondary manufactured materials); AR – recycled materials.		

The definitions for the alternative materials described in document are listed in Table 2. They were inspired by the CEN/TS 17438, however for earthworks additional materials are defined (see Table 2).

Material sheets were prepared for majority of materials described in Table 2. In case of no or not enough practical applications in earthworks no material sheets have been prepared. A list of materials without material sheet is below:

- A1 Reclaimed asphalt
- B2 Municipal incinerator fly ash (MIFA)
- E2 Ferromolybdenum slag
- E3 Zinc slag
- E4 Phosphorous slag
- E5 Lead slag
- E6 Ferrochromium slag
- F2 Foundry cupola furnace slag
- I2 Sewage sludge incineration ash (municipal)
- I4 Oil shale ash
- J2 Cement and lime kiln dust
- J4 FGD artificial gypsum
- J5 Industrial artificial gypsum
- J6 Marginal materials

Dredged material – coarse (class H2b) for application as hydraulic fill is described in EN 16907-6.

Reclaimed natural soil (without processing) is assessed according to EN 16907-1 to EN 16907- 6.

NOTE Marginal materials represent local sources (e.g. China clay residues, peat ash, etc.). They are assessed individually.

Table 2 — Definitions of alternative materials

Group	Source	EN 16907-2 Group	Group	Subnumber (CEN/TS 17438)	Specific material	Definition
A	Construction and demolition recycling industries	AR	A1	A1	Reclaimed asphalt	Material resulting from processing bituminous layers.
			A2	A2	Reclaimed concrete	Material resulting from processing concrete.
			A3	A3	Reclaimed bricks, masonry	Material resulting from processing demolition brick work and masonry.
			A4	A4	Hydraulically bound and unbound materials	Material resulting from processing hydraulically bound and unbound materials.
			A5	A5	Mix of A1, A2, A3 and A4	Material resulting from processing a mix of bituminous layers and/or concrete and/or demolition brick work and masonry.
			A6	A6	Reclaimed railway ballast	Material resulting from recycling of railway ballast.
B	Municipal solid waste incineration industry	AM	B1	B1	Municipal incinerator bottom ash ^a (excluding fly ash) (MIBA)	Material resulting from processing 'bottom ash' ^b following the incineration of Municipal Solid Waste (domestic and commercial) by a 'moving grate' or 'fluidised bed' or gasification' process. Today also referred to as MIBA (Municipal Incinerator Bottom Ash).
			B2	B2	Municipal incinerator fly ash (MIFA)	Material resulting from flue gas following the incineration of municipal solid waste (municipal and commercial) by a 'moving grate' or 'fluidised bed' or gasification' process, captured by flue gas treatment (FGT) systems and in some cases electrostatic precipitators'. Today also referred to as MIFA (Municipal Incinerator Fly Ash).

Group	Source	EN 16907-2 Group	Group	Subnumber (CEN/TS 17438)	Specific material	Definition
C	Coal Power generation industry	AM	C1a	C1	Coal fly ash - siliceous	Material resulting from flue gas following the burning of pulverised hard (or bituminous) coal, with or without co-combustion materials, captured by electrostatic precipitators.
			C1b	C1	Coal fly ash - calcareous	Material resulting from flue gas following the burning of pulverized lignite with or without co-combustion materials, captured by electrostatic precipitators.
			C2	C2	Fluidized bed combustion fly ash (FBCFA)	Material resulting from flue gas following coal burning with or without co-combustion in fluidized bed combustion boilers at temperatures of 750 °C to 900 °C.
			C3	C3	Boiler slag	Material resulting from coal combustion in boilers at temperatures of 1 500 °C to 1 700 °C, followed by wet ash removal of wet bottom furnaces.
			C4a	C4	Coal bottom ash-siliceous	Material resulting from the bottom of dry boilers, derived from the combustion of (hard or bituminous coal) coal with or without co-combustion.
			C4b	C4	Coal bottom ash - calcareous	Material resulting from the bottom of dry boilers, derived from the combustion of lignite with or without co-combustion.
			C5		Fluidized bed combustion bottom ash (FBC bottom ash)	Material resulting from the bottom of fluidized bed combustion boilers at temperatures of 800 °C to 900 °C, derived from the burning of coal with or without co-combustion.

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Group	Source	EN 16907-2 Group	Group	Subnumber (CEN/TS 17438)	Specific material	Definition
D	Iron and steel industry	AM	D1	D1	Granulated blast furnace slag (GBS) (vitrified)	Material resulting from the manufacture of iron by thermochemical reduction in a blast furnace and subsequently rapidly-cooled to form a glassy material. The rapid cooling (quenching) of the liquid slag generates the glassy granulated blast furnace slag.
			D2	D2	Air-cooled blast furnace slag (ABS) (crystallized)	Material resulting from the manufacture of iron by thermochemical reduction in a blast furnace and subsequently air-cooled to form a crystalline aggregate.
			D3	D3	Basic oxygen furnace slag (converter slag, BOS)	Material resulting from the conversion of liquid iron (hot metal) and steel scrap into steel during a batch process in a basic oxygen furnace.
			D4	D4	Electric arc furnace slag (from carbon steel production, EAF C)	Material resulting from melting steel scrap into steel during a batch process in an electric arc furnace.
			D5	D5	Electric arc furnace slag (from stainless/high alloy steel production, EAF S)	Material resulting from the manufacture of stainless or high alloy steel in different metallurgical vessels, e.g. electric arc furnace, converter and ladles.
			D6	D6	Secondary metallurgical slags (SMS)	Material resulting from the manufacture of carbon steel in different metallurgical vessels, e.g. ladles.
E	Non-ferrous industry	AM	E1	E1	Copper slag	Material resulting from the manufacture of copper in a furnace process.
			E2	E2	Ferromolybdenum slag	Material resulting from a metallo-thermic reduction process to produce ferromolybdenum from roasted molybdenite concentrate and other raw materials.
			E3	E3	Zinc slag	Material resulting from the pyrometallurgical step when treating zinc-bearing materials.
			E4	E4	Phosphorous slag	Material resulting from the manufacture of phosphorus in an electric arc furnace process.
			E5	E5	Lead slag	Material resulting from the manufacture of lead.
			E6	E6	Ferrochromium slag	Material resulting from ferrochromium production. Slag product processing starts from melt phase.

Group	Source	EN 16907-2 Group	Group	Subnumber (CEN/TS 17438)	Specific material	Definition
F	Foundry industry	AM	F1	F1	Foundry sand	Material obtained in iron, steel and malleable iron foundries as well as in non-ferrous foundries during core making, preparation of moulding material and after casting and shake out of the moulds.
			F2	F2	Foundry cupola furnace slag	Material resulting from operation of a cupola furnace in iron foundries.
G	Mining and quarry industry	AN	G1	G1	Red coal shale Burnt colliery spoil after burning	Material resulting from uncontrolled burning of colliery spoil on tips of bituminous coal.
			G2	G2	Refuse from hard coal mining (black coal shale). Unburnt colliery spoil from hard coal mining.	Material from black coal shale (black minestone).
			G3	G3	Pre-selected all-in from quarry/mining	Material from the quarry or the mining industry which has processed mechanically. It includes quarry spoils.
			G4	G4	Spent oil shale	Material resulting from oil shale processing by heating under poorly oxidizing conditions to extract the oil.

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Group	Source	EN 16907-2 Group	Group	Subnumber (CEN/TS 17438)	Specific material	Definition
H	Excavated natural materials	AN	H1a		Tunnel arisings from hard rocks traditional method	Coarse material excavated by blasting in hard rock by the traditional method (e.g. NATM – New Austrian tunnelling method).
			H1b		Tunnel arisings from hard rocks with TBM	Material excavated with a Tunnel Boring Machine in a hard rock.
			H1c		Tunnel arising from soft material Slurry shield	Material excavated with a slurry shield TBM.
			H1d		Tunnel arising from soft material Earth pressure	Material excavated with a TBM with earth pressure balance (EPB).
			H2a	H1	Dredge spoil - fine	Fine material excavated in lakes, dams, ports or rivers exhibiting a very moisture content and very low bearing capacity even after stockpiling.
			H2b	H1	Dredge spoil - coarse	Sandy or gravelly material excavated in lakes, dams, ports or rivers with permeability high enough to allow departure of free water after stockpiling.
			H3		Processed reclaimed natural soil	Material resulting from a screening or treatment process which leaves a residue of natural soils.
I	Other combustion residues	AM	I1	I1	Paper sludge ash	Material resulting from the incineration of paper sludge (from deinking process).
			I2	I2	Sewage sludge incineration ash (municipal)	Material resulting from the incineration of sewage sludge (mostly communal sludge) by a fluidised bed process.
			I3	I3	Biomass ash	Material resulting from the incineration of biomass.
			I4		Oil shale ash	Material resulting from incineration of oil shale.