Road and Transportation Research Association

Working Group on Aggregates, Unbound Pavements

FGSV

Fact sheet on the use of ferrous slag in road construction

M EHS

R 2

Edition 2013/Translation 2019

ISBN 978-3-86446-065-4

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Working Group on Aggregates, Unbound Pavements
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Foreword

The "Fact sheet on the use of ferrous slag in road construction" (M EHS), 2013 edition, was prepared by the "Ferrous slag" sub-group in the "Industrial By-Products and Recycled Aggregates" sub-committee (head: Dr.-Ing. H. Motz). It replaces the "Fact sheet on the use of granulated blast furnace slag in frost blanket and water-bound macadam courses", 1995 edition, the "Fact sheet on the use of steel works aggregate mixtures, secondary steelmaking slag and electric arc furnace slag from stainless/high-alloy steel production in road construction", 1998 edition, and the "Fact sheet on the use of ferrous slag in road construction", 1999 edition.

Coordination with the "Earthworks and Foundation Engineering" working group was achieved through its sub-group "Recycled Aggregates and Industrial By-Products".

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Preface

Sustainability has become one of the dominant themes of political and social debate. As a result, road construction activities are confronted with major and complex challenges. For instance, the inevitable need to intervene in the environment in any given construction activity must be assessed in terms of its ecological, economic and social impact. Ensuring a balance between these three aspects requires industry and discipline-specific strategies. One of these strategies relates to the selection and use of construction materials.

The importance of greater efficiency in the use of materials and the preservation of resources is apparent just by looking at the material flows involved in road construction. Extraction sites for mineral construction materials are being viewed increasingly critically in light of the obvious changes that this entails in the environment. At the same time, environmental policy requirements are already causing shortages of landfill space. As a result of statutory conditions and the requirements of general environmental protection standards, it is therefore necessary to make as complete and effective as possible the use of available industrial by-products and recycled aggregates.

Accordingly, the use of industrial by-products and recycled aggregates contributes to the most efficient use of construction materials, in keeping with the sustainability strategy of the German Federal Government and the EU Initiative for a Resource Efficient Europe. Fewer natural mineral commodities are extracted and landfill capacities are put under less strain.

Optimum usage always requires knowledge of the construction materials to be used and of their specific properties. The fact sheets of the FGSV regarding the use of industrial by-products and recycled aggregates therefore compile information that enables the best possible use of these construction materials in road construction.

Table 1: Potential applications for ferrous slag

Seq. no.	Field of application	Air-cooled blast furnace slag (ABS)	Granulated blast furnace slag (GBS)	Basic oxygen furnace slag (BOS)/Electric arc furnace slag from carbon steel production (EAF C)	Secondary steelmaking slag (SECS)	Electric arc furnace slag from stainless/ high-alloy steel production (EAF S)
1	**Road pavements**					
1.1	Asphalt surface courses and asphalt base courses according to ZTV Asphalt-StB and ZTV LW	+	+	+	–	–
1.2	Asphalt binder courses according to ZTV Asphalt-StB	+	+	+	–	–
1.3	Concrete pavements according to ZTV Beton-StB and ZTV LW	+	+	–	–	–
1.4	Hydraulically-bound base courses and hydraulically-bound surface courses in accordance with ZTV LW	+	+	–	–	–
1.5	Bedding and joint sealing for paved and slabbed surfaces in accordance with ZTV Pflaster-StB and ZTV LW	+	–	+	–	–
1.6	Surface courses without binders according to ZTV Asphalt-StB and ZTV LW	+	+	+	+	–
2	**Bound base courses**					
2.1	Asphalt base courses according to ZTV Asphalt-StB and ZTV LW	+	+	+	–	–
2.2	Base courses with hydraulic binders according to ZTV Beton-StB and ZTV LW	+	+	+	–	–
2.3	Base courses from hydraulically-bound mixtures according to EN 14227-2	+	+	+	–	–
3	**Base courses without binders**					
3.1	Base courses without binders according to ZTV SoB-StB	+	+	+	–	–
3.2	Base courses without binders according to ZTV LW	+	+	+	–	–
4	**Earthworks according to ZTV E-StB**					
4.1	Subgrade	+	+	+	+	+
4.2	Soakage systems and filter layers	+	–	–	–	–
4.3	Excavation pits and pipe trenches	+	+	+	+	+
4.4	Backfilling and covering structures	+	+	+	–	–
4.5	Protective barriers	+	+	+	+	+
4.6	Soil stabilisation	+	+	+	+	+
4.7	Soil improvement with binders	+	+	+	+	+
4.8	Mechanical soil improvement	+	–	+	–	–

+ = Use possible – = No use

1 Purpose and field of application

The “Fact sheet on the use of ferrous slag in road construction” (M EHS) describes the properties of ferrous slag (blast furnace slag and steelmaking slag) and the prerequisites for their use in urban road construction, rural road construction and earthworks.

Ferrous slag is given equal treatment alongside natural mineral materials in road construction regulations today, both at a national and European level. Practical experience in construction has shown that, for example, the cubic grain form and rough surface guarantee a high load capacity when laying base courses without binders, and these can be easily laid and directly driven on even under adverse weather conditions. Asphalt layers using ferrous slag also exhibit high resistance to deformation and – when used in surface courses – very good road grip.

The following sections break the individual slag types down based on their metallurgical processes and address each of the slag types separately in terms of their

- production and treatment,
- properties,
- application and
- requirements.

Fact sheets are suitable neither as a basis for contracts nor as a policy tool in connection with their main (primary) purpose. In connection with their secondary purpose, extracts of fact sheets or modified fact sheets can also form components of contracts for construction, delivery or engineering contracts (see “General road construction circular No. 26/1980; fundamentals for the preparation of technical sets of rules for road construction; types and contents”).

2 Terminology

DIN 4301 breaks down ferrous slag into blast furnace slag and steelmaking slag. Figure 1 lists the various types of slag.

Ferrous slag

- **Blast furnace slag (BFS)**
  - **Air-cooled blast furnace slag (ABS)**
  - **Granulated blast furnace slag (GBS)**
- **Steelmaking slag (SMS)**
  - **Basic oxygen furnace slag (BOS)**
  - **Electric arc furnace slag from carbon steel production (EAF C)**
  - **Secundary metallurgical slag (SECS)**
  - **Electric arc furnace slag from stainless/high-alloy steel production (EAF S)**
  - **Stored steel making slag (SSMS)**

Figure 1: List of slag types

Blast furnace slag is produced as a fused aggregate during the production of hot metal in a blast furnace. The product may be a crystalline **air-cooled blast furnace slag (ABS)** or a glassy fine-grained **granulated blast furnace slag (GBS)** depending on the cooling conditions.

Steelmaking slag (SMS) is produced when converting hot metal, direct reduced iron and processed steel scrap into steel. Depending on the steel production process used, the conversion process will first produce **basic oxygen furnace slag (BOS)** using the Linz-Donawitz process or **electric arc furnace slag from carbon steel production (EAF C)** using the electric arc process.

Modern steelmaking technology requires the crude steel produced in these process steps to be further treated in additional processes. This in turn produces steelmaking slag that is referred to as **secondary steelmaking slag (SECS)**.

Electric arc furnace slag from stainless/high-alloy steel production (EAF S) is steelmaking slag generated during the production of high-alloy steels.

The production of steelmaking slag using the open hearth process ceased in Germany at the end of 1993. However, there are still large amounts of slag produced using this method stored in Brandenburg, referred to as **stored steelmaking slag (SSMS)**. Specific technical conditions of delivery apply for SSMS in Brandenburg and Saxony-Anhalt.

A diagram of the basic process routes used to produce ferrous slag is shown in Figure 2.

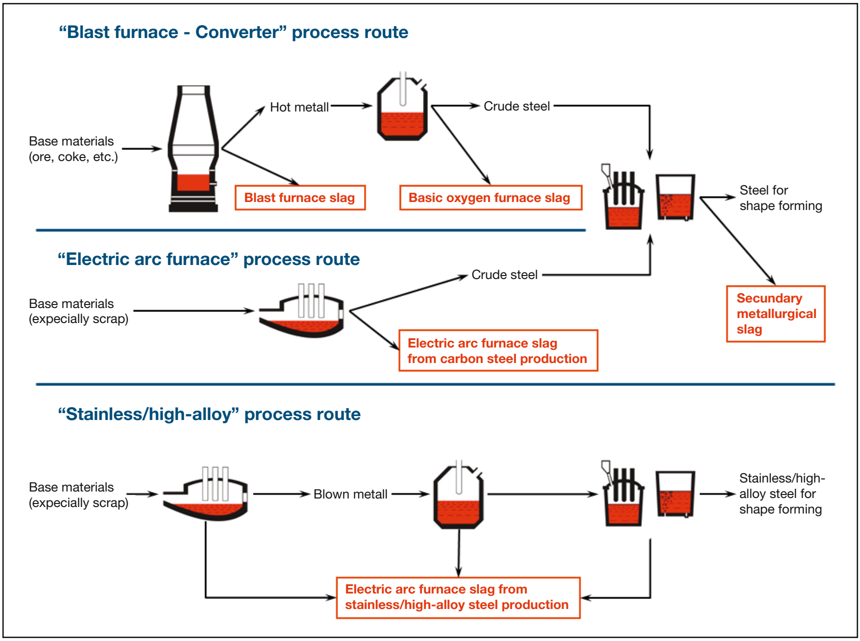

Figure 2: Schematic diagram of the production of ferrous slag

Figure 3 shows the current production locations in Germany. The geographical distribution of the steelworks means that ferrous slag is used in all of Germany's federal states today.

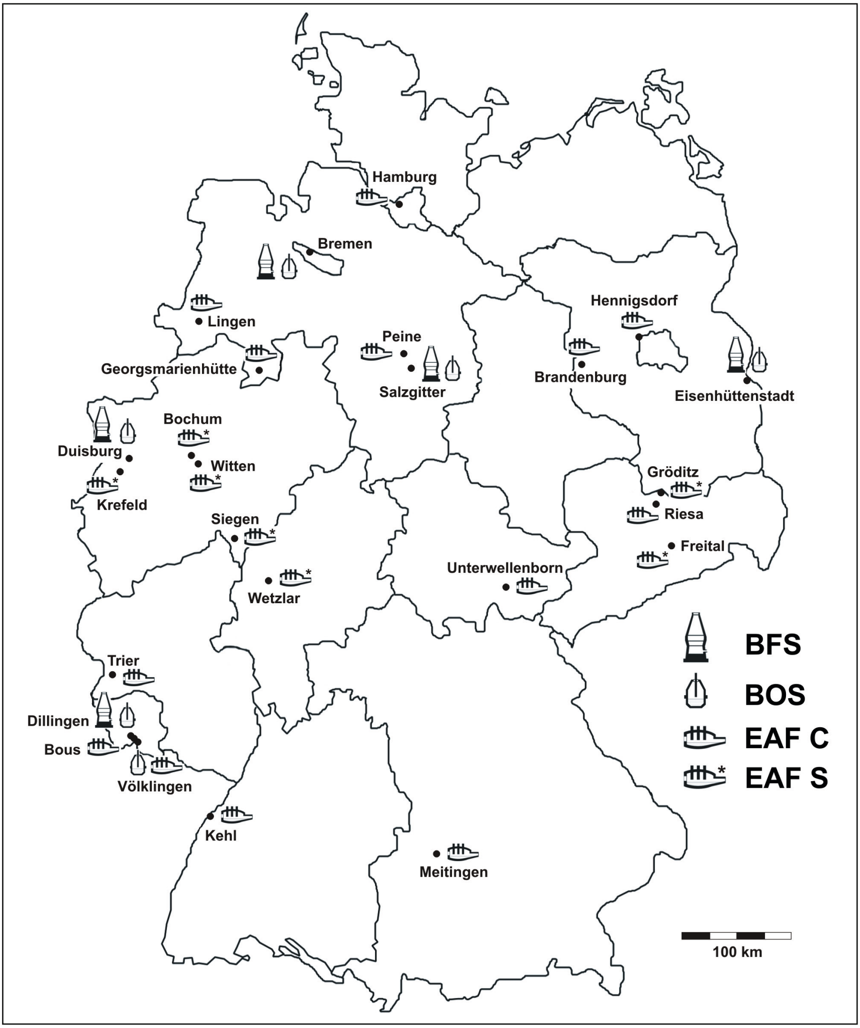

Figure 3: Production sites of ferrous slag in Germany

This fact sheet on ferrous slag does not address nonferrous slag (such as slag made from the production of lead or copper), nor do they include foundry slag (such as foundry cupola slag and electric arc furnace slag from foundries). These are addressed in their own fact sheets.

3 Blast furnace slag

3.1 Production and treatment

The fused aggregate produced in blast furnaces – a liquid blast furnace slag – can be processed into different products depending on the given cooling conditions.

If cooled slowly in slag pits, this produces a crystalline air-cooled blast furnace slag. Mechanical processing is an essential part of the production process. Once cooled, the ABS is dug and processed into aggregates or aggregate mixtures by crushing, sieving and proportioning.

If cooled quickly with water in granulation plants, this produces the glassy, fine-grained granulated blast furnace slag. Due to its latent hydraulicity it is mostly used as raw material for the production of cements or concrete additives. In road construction it is used as an aggregate or as a component in aggregate mixtures.

3.2 Properties

3.2.1 Composition

The chemical composition of ferrous slag is defined by the underlying raw materials and the metallurgical processes (see Figure 2). Slowly cooling liquid blast furnace slag to form an air-cooled blast furnace slag produces distinctive mineral phases. Air-cooled blast furnace slag consists mostly of calcium silicates. Non-reactive oxides such as unbound CaO or unbound MgO are not present in air-cooled blast furnace slag, as all oxide components are present as compounds or solid solutions. The mineral phases merwinite, åkermanite and gehlenite are dominant.

Granulated blast furnace slag has a glassy (non-crystalline) structure.

Typical ranges for the chemical composition of blast furnace slag are shown in Table 2. Typical mineral phases of air-cooled blast furnace slag are shown in Table 3.

3.2.2 Density

The particle density of ABS and GBS is generally between 2.0 and 2.8 Mg/m³, while the uncompacted bulk density is between 0.9 and 1.3 Mg/m³. Proctor compaction values and the optimum water content of aggregate mixtures are in part dependent on the bulk density and grain size distribution. Aggregate mixtures made of ABS or a combination of ABS and GBS generally have a Proctor density of between 1.6 and 2.0 Mg/m³ with an optimum water content of between 4 and 10 % by mass.

Table 2: Typical ranges for the chemical composition of the original substance of blast furnace slag (ABS and GBS)

Component (specified in oxide form*))	Content [% by mass]
CaO	34 – 43
SiO_2	35 – 40
MgO	7 – 16
Al_2O_3	8 – 12
Fe_2O_3	0.1 – 1.0
MnO	0.1 – 1.0
K_2O	0.3 – 0.9
Na_2O	0.1 – 0.8
SO_3	3.0 – 4.7

*) Information is provided – as is standard in geological sciences – using empirical formulas, even if the components occur as different mineral phases and in different stages of oxidation.

Table 3: Typical mineral phases of ABS

Name	Chemical formula
Merwinite	$Ca_3Mg(SiO_4)_2$
Åkermanite	$Ca_2MgSi_2O_7$
Gehlenite	$Ca_2Al_2SiO_7$

3.2.3 Volume stability

Due to the blast furnace metallurgy used in Germany the blast furnace slag produced has a high volume stability. The European product standards for aggregates continue to require testing for dicalcium silicate disintegration and iron disintegration, so these tests are still performed in Germany during third party control and factory production control.

3.2.4 Hardening

Unbound layers made of aggregate mixtures using ABS or GBS harden due to chemical reactions. It is generally important to differentiate between carbonate hardening of crystalline ABS and hydraulic hardening of glassy GBS.

In the case of ABS, calcium hydroxide generated when exposed to water reacts with CO from the air to form calcium carbonate, which causes a carbonate hardening effect. GBS as a latent hydraulic substance hardens when exposed to water. Adding a suitable catalyst can speed up this process. Both hardening processes may interfere with each other.

This effect is also described in DIN EN 14227-2 and may be used to produce self-hardening base courses (SHBC) in accordance with ZTV SoB-StB. Alongside mixtures made of ABS and GBS, mixtures with added SMS have also proven beneficial. The self-hardening results in a slow increase in the load-bearing capacity of the respective layer. The increase in load-bearing capacity is assessed by conducting CBR tests directly after production of the test specimens and after different storing periods.

3.2.5 Environmental aspects

The use of construction materials – regardless of their product status – must not result in adverse effects to the public welfare. The use of ABS and GBS in bound or unbound form in technical structures requires the protection of the soil and waters. Compliance with the limits laid down in TL Gestein-StB and in separate federal state regulations therefore is a prerequisite for the use of blast furnace slag in urban road construction, rural road construction and earthworks. In addition to the construction method and location of the construction activity, there may also be additional regulations to be accounted for at the construction site.

In connection with environmental concerns, it is important to consider beneath pH value and conductivity the sulphate leaching of blast furnace slag. The sulphur leached as sulphate is basically introduced into the blast furnace process by the coke used. The heavy metals introduced by additives are almost completely passed into the hot metal and into the gas phase due to the reductive conditions prevailing in the blast furnace. Organic components cannot be present in blast furnace slag due to the high production temperatures exceeding 1,500 °C.

Aside from the leaching tests that have been commonly performed for many years, a set of toxicological and eco-toxicological tests have been performed on blast furnace slag in preparation for the registration according to the REACH regulation. Based on the results blast furnace slag could be registered as non-hazardous substances at the European Chemicals Agency (ECHA).

The following names are used throughout Europe:

Table 4: Names of blast furnace slag in the context of REACH registration

Name in the context of REACH registration	German equivalent	CAS no. EINECS no.	Registration no.
Granulated blast furnace slag (GBS)	Hüttensand (HS)	65996-69-2 266-002-0	01-2119487456-25-XXXX
Air-cooled blast furnace slag (ABS)	Hochofenstück-schlacke (HOS)	65996-69-2 266-002-0	01-2119487456-25-XXXX

Remarks:
CAS: Chemical Abstracts Service
EINECS: European Inventory of Existing Commercial Chemical Substances
Registration no.: The last four digits are assigned specifically depending on the company/production facility.

3.3 Application

Blast furnace slag can be used in urban and rural road construction in layers with or without binders, and also in earthworks. It can also be used in mixtures with other construction materials. In terms of their environmental characteristics each component of such a mixture must comply with the specific requirements for the respective application.

The fields of use specified in Table 1 (see page 6) are the main ones to be considered. Beyond this, the water conditions prevailing in the resultant layer must also be considered when using ABS. This layer must not be in water that is static or draining extremely slowly ("waterlogging"), as sulphur compounds may contaminate the water under these conditions. Such conditions may arise e. g. when placing ABS above water-impermeable layers if side drainage of the water is prevented ("tub effect").

3.4 Requirements

The requirements regarding the properties of blast furnace slag are laid down in TL Gestein-StB, TL SoB-StB and TL BuB E-StB. The technical regulations relevant for the particular application must also be respected.

4 Steelmaking slag

4.1 Production and treatment

Steel today is produced in a multi-stage process (see Section 2) in order to meet today's steel quality standards. In the first step during the production of crude steel, BOS is produced in the LD converter, EAF C is produced in the electric arc furnace. When producing high-alloy steels ("high-grade steels") in special processes, EAF S is produced.

The further treatment of the crude steel is performed using special secondary metallurgical processes in which secondary steel making slag (SECS) is produced. The individual SMS types are poured at around 1,600 °C into pans or pits where they slowly solidify from a fused into a crystalline aggregate. Depending on their composition and cooling conditions, they may take the form of coarsely or finely-grained slag.

Mechanical processing is an essential part of the production process of SMS. Once cooled into a crystalline rock, SMS is dug and processed into aggregates or aggregate mixtures by crushing, sieving and proportioning.

4.2 Properties

4.2.1 Composition

Under the conditions of the various steelmaking processes and process stages, calcium silicate or calcium alumosilicate slag is produced. It is mainly formed from the lime and/or dolomite added to form slag as well as from accompanying elements present in other base materials.

Slowly cooling liquid steelmaking slag produces distinctive mineral phases. The dominant phases are calcium silicates, calcium aluminates and iron oxides, mainly present as wüstites and calcium ferrites. Steelmaking slag may contain unbound oxides such as unbound CaO or unbound MgO that play a key role in volume stability (see Section 4.2.3).

Typical ranges for the chemical composition of the various steelmaking slag are shown in Table 5. Typical mineral phases are shown in Table 6.

4.2.2 Density

Due to the content of iron oxides the particle density of SMS is usually between 3.2 and 3.90 Mg/m^3.

Proctor density and optimum water content of aggregate mixtures are in part dependent on the particle density and grain size distribution. Aggregate mixtures made of SMS generally have Proctor densities of between 2.0 and 2.6 Mg/m^3 with an optimum water content of between 4 and 10 % by mass.

Table 5: Typical ranges for the chemical composition of the original substance of steelmaking slag

Component (specified in oxide form*))	Content [% by mass]			
	BOS	EAF C	SECS	EAF S
CaO	43 – 53	20 – 36	25 – 60	20 – 60
Free CaO	2 – 9	< 1	< 1 – 15	1 – 20
SiO_2	11 – 18	10 – 18	3 – 30	10 – 40
MgO	1 – 8	3 – 7	2 – 20	1 – 15
Al_2O_3	1 – 5	4 – 9	3 – 40	1 – 12
Fe_2O_3	20 – 31	29 – 48	1 – 60	0.1 – 10
MnO	2 – 5	4 – 8	0.1 – 6	0.1 – 4
P_2O_5	1 – 3	0.5 – 1	0.02 – 1	0.02 – 0.7

*) Information is provided – as is standard in geological sciences – using empirical formulas, even if the components occur as different mineral phases and in different stages of oxidation.

Table 6: Typical mineral phases of SMS

Name	Chemical formula	BOS	EAF C	SECS	EAF S
Dicalcium silicate	Ca_2SiO_4	+	+	+	+
Tricalcium silicate	Ca_3SiO_5	+			
Merwinite	$Ca_3Mg(SiO_4)2$		+		+
Åkermanite/gehlenite	$Ca_2MgSi_2O_7/Ca_2Al_2SiO_7$		+		+
Wüstite	FeO	+	+		
Magnetite	$FeFe_2O_4$	+			+
Brownmillerite	$Ca_2(Al,Fe)2O_5$		+		
Dicalcium ferrite	$Ca_2Fe_2O_5$	+	+		
Free lime	CaO	+		(+)	(+)
Periclase	MgO			(+)	(+)
Mayenite	$Ca_{12}Al_{14}O_{33}$			+	+

(...) = Dependent on chemical composition

If SMS is used in asphalt courses, the minimum binder content values specified in TL Asphalt-StB for the various mixture types must be adjusted by a factor to take into account the high particle density. Otherwise, the required minimum binder content may not be met during the initial type testing.

As with all rocks that have a high particle density as well as a high porosity, it is also very important to take into account the pores when determining binder content and void content. Depending on the proportion, size, distribution and accessibility of the pores, it may be beneficial to determine the particle density using water or a solvent. DIN EN 12697-5 provides basic information on selecting the appropriate test method.

4.2.3 Volume stability

In SMS there may be chemically unbound calcium oxide and magnesium oxide respectively present, known as free lime and free magnesium oxide. Because these mineral phases absorb water and increase in volume as a result, adequate volume stability must be proved for certain applications in urban road construction, rural road construction and earthworks. This is why laboratory testing methods have been developed to test volume stability. These are laid down in DIN EN 1744-1 and TP Gestein-StB and are performed in connection with factory production control. The magnitude of expansion generated during laboratory testing will not apply directly to the construction project itself. Comparative tests have shown that the permissible expansion in laboratory testing is of such a magnitude that no elevation occurs in the constructions.

4.2.4 Hardening

When using aggregate mixtures made of SMS in layers without binder, calcium hydroxide generated when exposed to water reacts with CO from the air to form calcium carbonate. During this formation of carbonatic mineral phases, the layers made of SMS will harden during usage.

This effect is also described in DIN EN 14227-2 and may be used to produce self-hardening base courses (SHBC) in accordance with ZTV SoB-StB. Alongside mixtures made of ABS and GBS, mixtures with added SMS have also proven beneficial. The self-hardening results in a slow increase in the load-bearing capacity of the respective layer. The increase in load-bearing capacity is assessed by conducting CBR tests directly after production of the test specimens and after different storing periods.

4.2.5 Environmental aspects

The use of construction materials – regardless of their product status – must not result in adverse effects to the public welfare. The use of SMS in bound or unbound form in technical structures requires the protection of the soil and waters. Compliance with the limits laid down in TL Gestein-StB, TL BuB E-StB and in separate federal state regulations is therefore a prerequisite for the use of SMS in urban road construction, rural road construction and earthworks. In addition to the construction method and location of the construction activity, there may also be additional regulations to be accounted for at the construction site.

Due to the base materials used SMS contains small concentrations of trace elements that are of environmental concern. Similar to natural rock, these elements are permanently integrated into the crystalline lattice of the slag.

The pH value and conductivity are also used to assess the eluate. CaO content of around 50 % by mass (see Table 5) may result in pH values greater than 12 and electrical conductivity of more than 6,000 µS/cm in laboratory eluates. Figure 4 shows the relationship between the pH value and electrical conductivity of a Ca(OH) solution as also typically generated for SMS eluates rich in calcium.

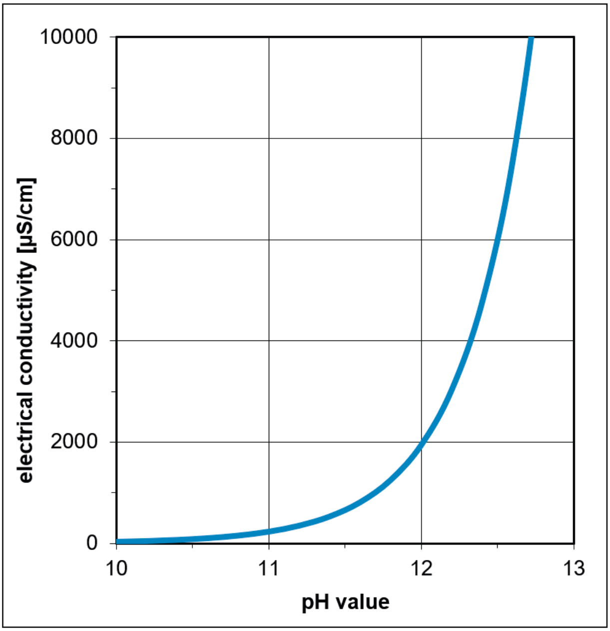

Figure 4: Dependency between the electrical conductivity of a Ca(OH) solution and its pH value

However, the values determined using the laboratory eluates do not apply directly to practical applications. Compared to the laboratory process, CO under practical conditions has greater access to seepage water, which causes part of the formed Ca(OH) to become carbonated. This results in a lower pH value and electrical conductivity. In some federal states, therefore the eluate may be aerated with CO_2. This results in a decline in Ca(OH), such that the conductivity is more representative of practical conditions.

Organic components cannot be present in SMS due to the high production temperatures exceeding 1,600 °C.

Aside from the leaching tests that have been commonly performed for many years, a set of toxicological and eco-toxicological tests have been performed on steelmaking slag in preparation for the registration according to the REACH regulation. Based on the results steel making slag could be registered as non-hazardous substances at the European Chemicals Agency (ECHA). The following names are used throughout Europe:

Table 7: Names of steelmaking slag in the context of REACH registration

Name in the context of REACH registration	German equivalent	CAS no. EINECS no.	Registration no.
Basic oxygen furnace slag (BOS)	LD-Schlacke (LDS)	91722-09-7 294-409-3	01-2119487458-21-XXXX
Electric arc furnace slag from carbon steel production (EAF C)	Elektroofenschlacke (EOS)	(91722-10-0) 932-275-6	01-2119485979-09-XXXX
Electric arc furnace slag from stainless/high-alloy steel production (EAF S)	Edelstahlschlacke (EDS)	(91722-10-0) 932-476-9	01-2119488921-27-XXXX
Steelmaking slag (SMS)	Other steelmaking slag, especially sekundärmetallurgische Schlacke (SEKS)	65996-71-6 266-004-1	01-2119487457-23-XXXX

Remarks:
CAS: Chemical Abstracts Service
(…) These CAS numbers meanwhile have been withdrawn, although some lists still show them. New (different) CAS numbers are expected to be assigned.
EINECS: European Inventory of Existing Commercial Chemical Substances
Registration no.: The last four digits are assigned specifically depending on the company/production facility.

4.3 Application

Steelmaking slag can be used in urban and rural road construction in layers with or without binders, and also in earthworks. The fields of use specified in Table 1 are the main ones to be considered.

SMS can also be used in mixtures with other construction materials. In terms of their environmental characteristics each component of such a mixture must comply with the specific requirements for the respective application.

4.4 Requirements

The requirements regarding steelmaking slag are laid down in TL Gestein-StB, TL SoB-StB and TL BuB E-StB. The technical regulations relevant for the particular application must also be respected.

To ensure volume stability, the construction of road embankments and protective walls subject to post-completion construction development (e.g. with noise barriers), Category 1 according TL BuB E-StB should generally be selected due to the greater thickness of the construction compared to base courses. If the supplied material is being overlaid with non hydraulically hardening, weather-resistant aggregate mixtures of at least 1 m thickness, Category 2 according TL BuB E-StB is sufficient. If no construction development of the earthworks is planned, Category 3 according TL BuB E-StB can also be selected.

5 Evidence of conformity/quality control

Evidence of conformity and quality control of ferrous slag is based on TL Gestein-StB, TL G SoB-StB and TL BuB E-StB. Environmentally critical properties are tested in connection with suitability certification and also twice a year in the context of factory production control and third party control respectively.

Technical Regulations

DIN	DIN 4301	Ferrous and non-ferrous metallurgical slag for civil engineering and building construction use	1)2)
	DIN EN 1744-1	Test methods for chemical properties of aggregates – Part 1: Chemical analysis	1)2)
	DIN EN 12697-5	Asphalt – Test methods for hot mix asphalt – Part 5: Determination of the maximum density	1)2)
	DIN EN 13286-47	Unbound and hydraulically bound materials – Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling	1)2)
	DIN EN 14227-2	Hydraulically bound mixtures – Specifications – Part 2: Slag bound granular mixtures	1)2)
FGSV	TL Asphalt-StB	Technical delivery terms for asphalt mixture used in the construction of traffic area pavements, 2007/revised 2013 (R 1) (FGSV 797)	2)
	TL BuB E-StB	Technical delivery terms for soils and construction materials in road construction earthworks, 2009 (R 1) (FGSV 597)	2)
	TL G SoB-StB	Technical delivery terms for construction material mixtures and soils used in the construction of unbound granular layers in road construction: Quality control, 2004/revised 2007 (R 1) (FGSV 696)	2)
	TL Gestein-StB	Technical delivery terms for aggregates in road construction, 2004/revised 2007 (R 1) (FGSV 613)	2)
	TL SoB-StB	Technical delivery terms for construction material mixtures and soils used in the construction of unbound granular layers in road construction, 2004/revised 2007 (R 1) (FGSV 697)	2)
	TP Gestein-StB	Technical testing regulations for aggregates in road construction (R 1) (FGSV 610)	2)
	ZTV Asphalt-StB	Additional technical conditions of contract and directives for the construction of asphalt traffic area pavements, 2007/revised 2013 (R 1) (FGSV 799)	2)
	ZTV Beton-StB	Additional technical conditions of contract and directives for the construction of base courses with hydraulic binders and concrete pavements 2007 (R 1) (FGSV 899)	2)
	ZTV E-StB	Additional technical conditions of contract and directives for earthworks in road construction, 2009 (R 1) (FGSV 599)	2)
	ZTV LW	Additional technical conditions of contract and directives for the pavement of rural paths and ways, 2007 (R 1) (FGSV 675)	2)

Technical regulations – continued

FGSV	ZTV Pflaster-StB	Additional technical conditions of contract and directives for the construction of block pavements, slab pavements, and edgings, 2006 (R 1) (FGSV 699)	2)
	ZTV SoB-StB	Additional technical conditions of contract and directives for the construction of unbound granular layers in road construction, 2004/revised 2007 (R 1) (FGSV 698)	2)
		Information sheet on the use of slag from metalworks in road construction, 2016 (R 2) (FGSV 639)	2)
		Information sheet on the use of residual matter from foundries in road construction, 1999 (R 2) (FGSV 641)	2)
Other	BTL SWLS-StB	Brandenburg technical conditions of delivery for stored steelmaking slag used in road construction Brandenburg Ministry for Infrastructure and Agriculture; State Highways Agency	*)
	TL SWLS-StB	Technical conditions of delivery and guidelines for the quality control of stored steelmaking slag used in road construction State Road Construction Agency of Saxony-Anhalt	

Reference sources:

1) **Beuth Verlag GmbH**
Address: Burggrafenstr. 6, 10787 Berlin, Germany
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2) **FGSV Verlag GmbH**
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*) www.ls.brandenburg.de → Informationen für das Fachpublikum → Straßenbautechnik → Technische Regelungen

All FGSV regulations listed are also available digitally for the FGSV Reader and are included in the comprehensive “FGSV – Technical Regulations – Digital” subscription.

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Production and sales:
FGSV Verlag GmbH
Wesselinger Strasse 15-17, 50999 Köln, Germany
Phone: +49 (0) 22 36 / 38 46 30 · Fax: +49 (0) 22 36 / 38 46 40
Internet: www.fgsv-verlag.de
ISBN 978-3-86446-065-4

R 2

634 E/3/14