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European Assessment Document for

Fibres for concrete - steel fibres recovered from end-of-life tyres

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

This EAD specifies assessment methods for fibres for concrete made from steel fibres recovered from end-of-life tyres (abridged here as RTSF: “Reused Tyre Steel Fibres”). The basic material is cold-drawn wire used in the manufacturing of tyre steel cords. Typical RTSF is shown in Figure 1.1.1.

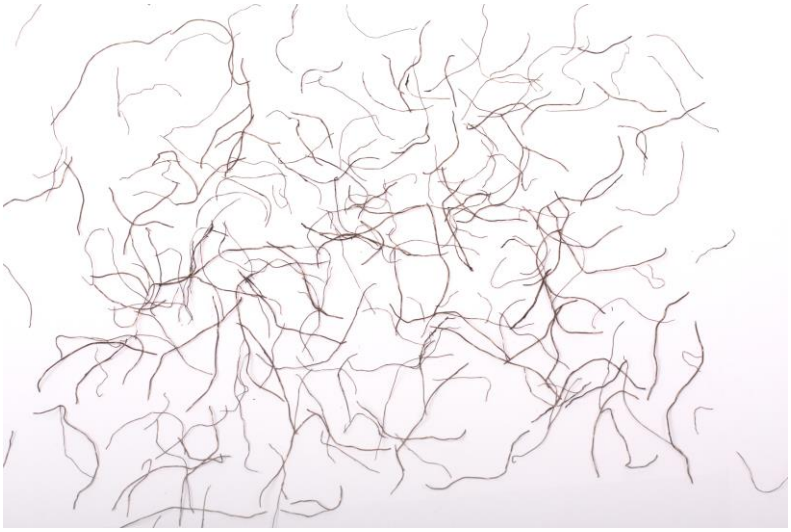
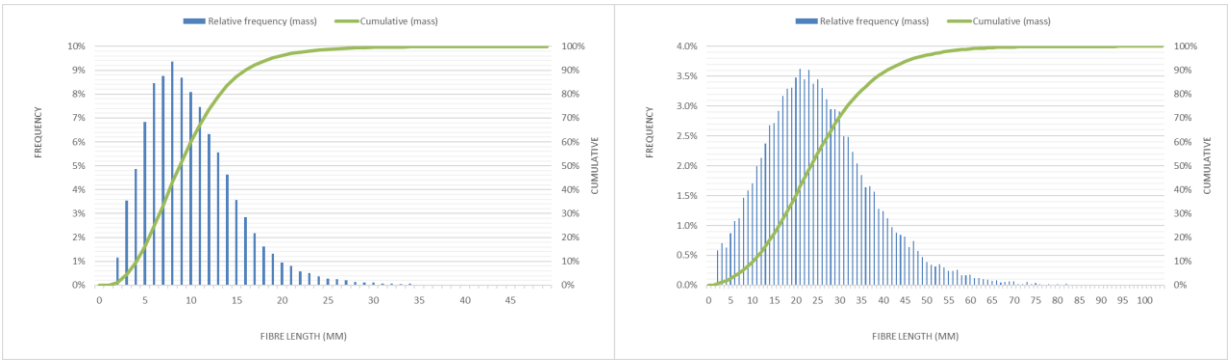


Figure 1.1.1 Typical RTSF

The geometrical characteristics (developed lengths and diameter) of RTSF shall be expressed in the form of statistical distributions (examples of the expression of such distributions are given in Figure 1.1.2). While the assessment method regarding the determination of the tensile strength of fibres requires the developed length of a specimen to be at least 20 mm, the statistical distribution of the developed length of the product implies a fraction of fibres of greater length suitable for testing. The developed lengths could be up to 100 mm. The diameter ranges from 0,1 mm to 0,4 mm or even above this diameter (more than 0,4 mm). The EAD is applicable to RTSF irrespective of the developed length and diameter of the fibres. The product may contain vulcanised rubber. This EAD is applicable for RTSF with rubber contents below 10% by mass.



(a) (b)

Figure 1.1.2 Examples of RTSF statistical length distributions: (a) short; (b) long

The product is not fully covered by the following harmonised technical specification: EN 14889-1[1], as this standard does not comprise provisions for a recycled steel fibre group. In particular, the following characteristics cannot be determined according to the method foreseen in EN 14889-1:

1 All undated references to standards or to EADs in this EAD are to be understood as references to the dated versions listed in chapter 4.

- tensile strength of fibres: taking into account the geometrical properties of the RTSF, the size and mounting of the specimens requires additional specifications to the reference test method foreseen in EN 14889-1;
- modulus of elasticity of fibres: taking into account that the modulus of elasticity is to be given for the basic material before deformation and that, due to the origin of RTSF, the basic material prior to the deformation of the fibres is not available, the modulus of elasticity of the fibres cannot be determined (similarly to Group III, IV and V of EN 14889-1, see clause 5.4).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The RTSF are intended for structural use in concrete, mortar and grout as defined in EN 14889-1.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the RTSF for the intended use of 50 years when installed in the works. These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product, the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[2].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

For specific terms used in this EAD refer to EN 14889-1, ISO 3534-1 and EN ISO 6892-1.

1.3.1 Crack Mouth Opening Displacement (CMOD)

Linear displacement measured by a transducer installed on a prism subjected to a centre-point load.

[2] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of RTSF is assessed in relation to the essential characteristics.

Table 2.1.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Tensile strength of fibres	2.2.1	*Level*
2	Effect on consistence (workability) of concrete	2.2.2	*Level*
3	Effect on strength of concrete	2.2.3	*Level*
Basic Works Requirement 3: Hygiene, health and the environment			
4	Content, emission and/or release of dangerous substances	2.2.4	*Level*

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

2.2.1 Tensile strength of fibres

The tensile strength shall be determined using a uniaxial tensile testing equipment in accordance with EN ISO 6892-1 Annex G, except as indicated below, and shall be stated in the ETA.

Test pieces with a minimum length of 20 mm shall be mounted on snubbing grips (e.g., countersunk snubbing grips shown in Figure 2.2.1.1) with at least 1 mm radius, to increase the probability of failure occurring at the free length of the specimen and produce valid test results. Results from specimens failing at the grip shall be ignored. Specimens shorter than 20 mm shall be discarded as they cannot reliably produce valid test results. The original cross-sectional circular area shall be calculated from the arithmetic mean of two measurements of the diameter carried out in two perpendicular directions to an accuracy of 0,01 mm.

The test shall be performed on 10 samples of at least 10 fibres each.

The tensile strength per individual specimen of fibre, being the maximum force measured for a fibre, divided by the cross-sectional area of that fibre, shall be recorded.

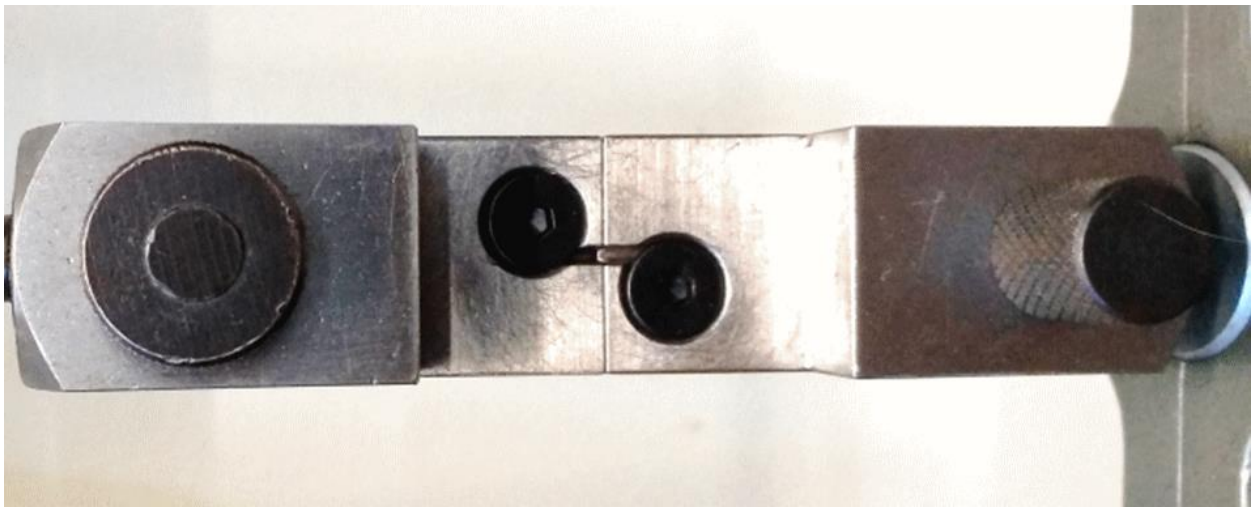


Figure 2.2.1.1 Countersunk snubbing grips for RTSF tensile tests

The resulting recorded tensile strength per individual specimen of fibre of all samples, representing all 100 measurements made, shall be arranged in descending order and the 90th value obtained from the top shall be presented in the ETA as the result of the assessment. If the number of measurements is greater than 100, the rank of the value that is presented in the ETA is increased linearly. This result shall be expressed in N/mm².

2.2.2 Effect on consistence (workability) of concrete

The effect of RTSF on the consistency (workability) of fresh concrete shall be determined on a reference concrete with a water/cement factor of 0,55, maximum aggregate size of 16 mm, cement content of 350 kg/m³. The compressive strength class of the concrete shall be at least C25/30, yet not higher than C40/50, determined according to EN 206 on 3 samples.

A default amount of fibres of 10 kg per m³ concrete shall be used. If additional testing is necessary, the amount of fibres shall be adjusted in steps of 0,5 or 1,0 kg depending on the results obtained. Additional testing is necessary if the concrete with fibres does not meet the strength requirements according to clause 2.2.3. As a second option for additional testing the manufacturer may choose the amount of fibres used.

The consistency according to EN 12350-3 (Vebe test) shall be determined on 3 specimens of the reference concrete without fibres and then on 3 samples of an identical mix with fibres. The arithmetic mean Vebe time (s) for concrete with and without fibres shall be stated in the ETA.

2.2.3 Effect on strength of concrete

The effect of RTSF on strength of concrete shall be determined according to EN 14889-1, Clause 5.8 with the exception of the specification of the reference concrete. The reference concrete composition shall be specified as water/cement factor of 0,55, maximum aggregate size of 16 mm, cement content of 350 kg/m³. The compressive strength class of the concrete shall be at least C25/30, yet not higher than C40/50, determined according to EN 206 on 3 samples.

A default amount of fibres of 10 kg per m³ concrete shall be used. If additional testing is necessary, the amount of fibres shall be adjusted in steps of 0,5 or 1,0 kg depending on the results obtained. Additional testing is necessary if the concrete with fibres does not meet the strength requirements below. As a second option for additional testing the manufacturer may choose the amount of fibres used.

The effect on strength of concrete shall be determined on 12 specimens.

The dosage of fibres in kg/m³ that achieves for all specimens a residual flexural strength of at least 1,5 MPa at 0,5 mm CMOD (equivalent to 0,47 mm central deflection) and a residual flexural strength of at least 1 MPa at 3,5 mm CMOD (equivalent to 3,02 mm central deflection) shall be determined and stated in the ETA.

2.2.4 Content, emission and/or release of dangerous substances

2.2.4.1 General

The performance of the RTSF regarding the emissions and/or release and, where appropriate, the content of dangerous substances will be assessed on the basis of the information provided by the manufacturer[3] after identifying the release scenarios taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market.

The identified intended release scenarios for RTSF and intended use with respect to dangerous substances are:

IA1: Product with direct contact to indoor air

IA2: Product with indirect contact to indoor air (e.g., covered products) but possible impact on indoor air

S/W1: Product with direct contact to soil, ground- and surface water.

S/W2: Product with indirect contact to soil, ground- and surface water.

2.2.4.2 SVOC and VOC

For the intended use covered by the release scenario IA1 and/or IA2 semi-volatile organic compounds (SVOC) and volatile organic compounds (VOC) shall be determined in accordance with EN 16516. The loading factor used for emission testing shall be 1,4 m^2/m^3.

The preparation of the test specimen is performed by using a representative sample of the product installed in accordance with the manufacturer's product installation instructions or in absence of such instructions the usual practice of the product installation.

Once the test specimen has been produced, as described above, it should immediately be placed in the emission test chamber. This time is considered the starting time of the emission test.

The test results have to be reported for the relevant parameters (e.g., chamber size, temperature and relative humidity, air exchange rate, loading factor, size of test specimen, conditioning, production date, arrival date, test period, test result) after 3 and/or 28 days testing.

The product performance shall be stated in the ETA [unit mg/m^3].

2.2.4.3 PAH and B[a]P

The assessment method for the content of specific organic compounds (PAH and B[a]P) is based on the raw material according to the testing method described in the document AfPS GS 2019:01 PAK [4] (Annex: Testing instructions, ´Harmonised method for the determination of polycyclic aromatic hydrocarbons (PAH) in polymers´).

The product performance to be stated in the ETA take into account the concentration of single PAH and/or the sum of PAH in mg/kg, as applied by the client.

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3 The manufacturer may be asked to provide to the TAB the REACH related information which he must accompany the DoP with (cf. Article 6(5) of Regulation (EU) No 305/2011).

The manufacturer is **not** obliged:

- to provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
- to provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS, taking into account the installation conditions of the construction product and the release scenarios resulting from there.

Any information provided by the manufacturer regarding the chemical composition of the products is not to be distributed to EOTA to other TABs or beyond.

4 *Currently, a European harmonized test procedure for PAHs is being developed. Until the publication of this test procedure (deadline 31.12.2022), the GC method according to ISO 18287 is optional.*

2.2.4.4 Nitrosamines

The assessment method for the content of nitrosamines has to be determined based on the raw materials following the method DGUV Information 213-523 published by DIK (Deutsches Institut für Kautschuktechnologie e.V. in Hannover, Germany). The sample to be tested is a composite sample taking at least four incremental samples collected from different areas of a batch to represent the raw material as good as possible.

Immediately before analysis, the rubber content is separated from the metal fibres by mechanical means. About 2 g of this rubber is transferred to a 30 ml extraction thimble used for Soxhlet-extraction. Subsequent, extraction is performed for 24 hours at 65 °C using 75 ml N-nitrosamine-free methanol with 0,1 %wt ascorbic acid in a 100 ml round bottom flask containing two boiling stones made of glass. After cooling down, 2 ml of N-nitrosodiisopropylamine (NDiPA, approximately 0.2 µg/ml) are added as internal standard. Following, the extract is evaporated with approximately 3,5 ml/min to about 5 ml using a rotary evaporator with a 40 °C water bath and 220±10 mbar.

The resulting pre-concentrate is transferred to a test tube using a Pasteur pipette. The round bottom flask is rinsed twice with 1 ml N-nitrosamine-free methanol and the rinse solution is pooled with the preconcentrate. By treatment with a nitrogen stream (0,05 ml/min) the solution is adjusted to 2 ml. Extracts with high oil content need chromatographic purification. The sample is analysed within 48 hours using packed columns.

The analysis of extracted N-nitrosamines is achieved by gas chromatography using a thermal energy analyser (TEA) as detector. The conditions for gas chromatographic analysis are shown in Table 2.2.4.4.1.

Table 2.2.4.4.1 Conditions for gas chromatographic analysis of N-nitrosamines

Nitrosamine	*NDMA, NDEA, NDPA, NDBA, NPIP, NPYR, NMOR, NDiPA*	*NMPA, NEPA*
column	*silanzed glas column (l = 2 m, ID = 1 mm)*	
Stat. phase	*10% Carbowax 20 M, 2% KOH on Chromosorb HAW 80/100 mesh*	*10% OV 101 on Chromosorb HAW 80/100 mesh*
Carrier gas	*helium*	
Carrier gas flow	*30 ml/min*	
Sample injection	*on column*	
Injector temperature	*200 °C*	
Temperature program	*125 °C 2 min isothermal 125 °C – 175 °C (10 °C/min) 175 °C 5 min isothermal*	*100 °C – 200 °C (10 °C/min)*
Sample volume	*5 µl*	*5 µl*

The N-nitrosamines to be determined are:

- N-nitrosodibutylamine (NDBA)
- N-nitrosodiethylamine (NDEA)
- N-nitrosodimethylamine (NDMA)
- N-nitrosodipropylamine (NDPA)
- N-nitrosomethylphenylamine (NMPA)
- N-nitrosoethylphenylamine (NEPA)
- N-nitrosomorpholine (NMOR)
- N-nitrosopiperidine (NPIP)
- N-nitrosopyrrolidine (NPYR)

The content of the N-nitrosamines shall be stated in the ETA [µg/kg] on the basis of the specific level.

2.2.4.5 Test on solids and leaching test

For the intended use covered by the release scenario S/W1 the total content and the leachable substances of the RTSF shall be determined.

For the following parameters, the total content shall be determined on three representative samples after aqua regia digestion in accordance with CEN/TS 17196:

arsenic (As), lead (Pb), cadmium (Ca), total chromium (Cr), copper (Cu), nickel (Ni), mercury (Hg), thallium (TI), zinc (Zn).

The analysis of the parameters shall be in accordance with CEN/TS 17201. The average of the measured values of each parameter shall be expressed in mg/kg and stated in the ETA.

Three representative samples of the RTSF shall be eluted in accordance with EN 12457-4. The following parameters in the eluate shall be determined using the methods for analysis in accordance with CEN/TS 17195:

1. arsenic (As), lead (Pb), cadmium (Ca), total chromium (Cr), copper (Cu), nickel (Ni), mercury (Hg), zinc (Zn) and
2. pH value, electrical conductivity.

The average of the measured values of each substance mentioned in No. 1 shall be expressed in µg/L, or mg/l and stated in the ETA.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 99/469/EC[5] of 17/07/1999, as amended by Commission Decision 2001/596/EC[6] of 8 January 2001.

The system is: 1, for structural uses in concrete, mortar or grout.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

Table 3.2.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Distribution of lengths	3.4.1.1	According to Control plan	1000 fibres	Once per 10 t
2	Distribution of diameters	3.4.1.2	According to Control plan	10 fibres (micrometre method) 1000 fibres (optical method)	Once per 10 t
3	Rubber content	3.4.1.3	According to Control plan	10 samples of 0,3 kg	Once per 10 t
4	Tensile strength of fibres	2.2.1	According to Control plan	30 fibres	Once per 10 t

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for RTSF are laid down in Table 3.3.1.

5 OJ L 184, 17.7.1999, p. 27

6 OJ L 209, 2.8.2001, p. 33

Table 3.3.1 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the RTFS.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control					
2	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1	According to Control plan	According to Control plan	Once per year

3.4 Special methods of control and testing used for the assessment and verification of constancy of performance

3.4.1 Distribution of developed lengths and diameters and rubber content

The characteristics of a defined RTSF depend on the geometrical characteristics (developed lengths and diameter) of the RTSF, which follow a recorded statistical distribution. Therefore, the distribution of lengths and distribution of diameters shall be assessed as per the control plan and compared to the recorded statistical distribution.

3.4.1.1 Distribution of developed lengths

The population characteristics of developed lengths (range, mean, standard deviation, coefficient of skewness and kurtosis), as well as upper and lower limits for 80% of the sample shall be determined and recorded. These shall not deviate from the values calculated from the length distribution used for determination of effect on consistency (workability) of concrete and effect on strength of concrete by more than 20%. The developed length data is best described by the lognormal probability distribution (see ISO 3534-1).

The developed lengths of individual fibres shall be determined using optical methods with an accuracy of 15%.

The test shall be performed on 1 sample of at least 1000 fibres.

The samples shall be collected at equally spaced intervals during a single production shift, taking into account the production volumes as per the control plan.

3.4.1.2 Distributions of diameters

The population characteristics of diameters (range, mean, mode, standard deviation), as well as upper and lower limits for 80% of the population shall be determined and recorded. The diameter data is best described by a multimodal distribution.

The diameter of individual fibres shall be measured with a micrometre, in two directions, approximately at right angles, to an accuracy of 0,01 mm. The manufacturer may determine the fibre diameters by an optical method to an accuracy of 20%.

When using a micrometre, the test shall be performed on a single sample, consisting of at least 10 fibres. When using an optical method, the test shall be performed on a single sample, each sample consisting of at least 1000 fibres. Both methods produce similar results; the micrometre method being the reference method. The optical method is more suited for in-line automated determination or for high production volumes.

3.4.1.3 Rubber content

The rubber content in RTSF shall be determined through burn tests at approximately (500 +/- 20) °C, for at least 30 minutes and recorded. The difference in mass shall be obtained with a scale of 0,001 g resolution.

The test shall be performed on 10 samples of at least 0,3 kg each. The samples shall be collected at equally spaced intervals during a single production shift.

4 REFERENCE DOCUMENTS

EN 206:2013+A2:2021	Concrete - Specification, performance, production and conformity
EN 12350-3:2019	Testing fresh concrete - Part 3: Vebe testEN 12457-4:2002 Characterisation of waste - Leaching - Compliance test for leaching of granular waste materials and sludges - Part 4: One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 10 mm (without or with size reduction)
EN 14889-1:2006	Fibres for concrete – Part 1: Steel fibres - Definitions, specifications and conformity
EN 16516:2017+A1:2020	Construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air
CEN/TS 17195:2018	Construction products: Assessment of release of dangerous substances - Analysis of inorganic substances in eluates
CEN/TS 17196:2018	Construction products: Assessment of release of dangerous substances - Digestion by aqua regia for subsequent analysis of inorganic substances
CEN/TS 17201:2018+AC:2018	Construction products: Assessment of release of dangerous substances - Content of inorganic substances - Methods for analysis of aqua regia digests
ISO 3534-1:2006	Statistics – Vocabulary and Symbols – Part 1: General statistical terms used in probability
ISO 18287:2006	Soil quality — Determination of polycyclic aromatic hydrocarbons (PAH) - Gas chromatographic method with mass spectrometric detection (GC-MS)
EN ISO 6892-1:2019	Metallic materials – Tensile testing – Part 1: Method of test at room temperature
AfPS GS 2019:01	Harmonised method for the determination of polycyclic aromatic hydrocarbons (PAH) in polymers (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin)
DGUV Information 213-523:2021	Analysis procedure for the determination of N-nitrosamines (Berufsgenossenschaft Rohstoffe und chemische Industrie)