INTERSTATE COUNCIL FOR STANDARDIZATION, METROLOGY AND CERTIFICATION

(ISC)

GOST

31938-2012

INTERSTATE STANDARD

FIBRE-REINFORCED POLYMER BAR FOR CONCRETE REINFORCEMENT

General Specifications

(ISO 10406-1:2008, NEQ)

Official Revision

Moscow

Standartinform

2014

Preface

Objectives, basic principles and common procedure for interstate standardization in construction are set forth in GOST 1.0–92 «Interstate Standardization System. Basic Provisions» and GOST 1.2–2009 «Interstate Standardization System.Interstate Standards, Regulations and Guidelines for Interstate Standardization. Rules for Compilation, Acceptance, Implementation, Update and Cancellation»

Information on the Standard

1 The Standard is AUTHORED by Research and Development Design and Engineering and Technological Institute of Concrete and Reinforced Concrete «NIIZhB» named after Gvozdev A.A., OJSC «RDC «Stroitelstvo», LLC «Byisk Plant of Glass Plastics» with the assistance of LLC «TBM»

2 INTRODUCED by Technical Committee for Standardization TK 465 «Stroitelstvo»

3 IMPLEMENTED by Interstate Science and Engineering Commission for Standardization, Technical Regulations and Assessment of Compliance in Construction (Minutes No.41 dd. December 18, 2012)

Votes for:

Short name of the country as per MK (ISO 3166) 004–97	Code of the country as per MK (ISO 3166) 004–97	Short name of State Construction Administration Body
Azerbaijan	AZ	Gosstroy
Armenia	AM	Ministry of Local Construction
Belorussia	BY	Minstroyarkhitektury
Kyrgyzstan	KG	Gosstroy
Moldova	MD	Gosstroy
Russia	RU	Ministry of regional development
Tajikistan	TJ	Agency for construction and architecture Affiliated to the Government
Uzbekistan	YZ	Gosarkhitektstroy

4 The present standard has been compiled with the account major provisions of ISO 10406-1:2008 Fibre-reinforced polymer (FRP) reinforcement of concrete – Test methods – Part 1: FRP bars and grids.

Translated from the English language (en).

Conformity extent – non-equivalent (NEQ)

5 By No. 2004-ст Decree of Federal Agency for Technical Regulations and Metrology dd. December 27, 2012 interstate standard GOST 31938–2012 is deemed effected as a national standard of the Russian Federation effective January 1, 2014.

6 FIRSTLY INTRODUCED

Information regarding any amendments of this standard is published in annual information bulletin «National Standards» (as of January 1 of the current year) while the text of amendments is published in monthly information bulletin «National Standards». In case of revision (replacement) or cancellation of the present standard respective notice will be published in monthly information bulletin «National Standards». Respective information, notice and texts are also published in common use information system – on the official website of the Federal Agency for Technical Regulation and Metrology on the Internet

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INTERSTATE STANDARD

FIBRE-REINFORCED POLYMER BAR FOR CONCRETE REINFORCEMENT

General specifications

Effected on – 2014–01–01

1 Scope

This standard describes general technical specifications and applies to fibre-reinforced polymer bar (FPB) used for reinforcement of common and pre-stressed structures and elements used in environments of different levels of corrosive agents that meet the requirements for fire resistance as per GOST 30247 and fire safety as per GOST 30403.

This standard does not apply to fibre-reinforced polymer streamline profile bars and compound polymer flexible connections.

2 References

This standard references to the following documents:

GOST 8.207–76 National Measurement Assurance System. Direct Measurements by Means of Repeated Observations. Observation Result Processing. General Provisions

GOST 12.1.044–89 Occupational Safety Standard System.Fire and Explosion Hazard of Substances and Materials. Set of Tested Parameters and Tests

GOST 17.2.3.02–78 Environmental Control.Atmosphere. Regulations on Determination of Maximum Allowable Levels of Emission of Hazardous Substances by Industrial Facilities

GOST 166–89 (*ИСО* 3599–76) Calipers. Technical Specifications

GOST 427–75 Metal Rulers. Technical Specifications

GOST 3560–73 Steel Baling Wire. Technical Specifications

GOST 4651–82 Plastics. Methods of Compression Test

GOST 6507–90 Micrometers. Technical Specifications

GOST 7502–98 Metal Measure Tapes. Technical Specifications

GOST 10884–94 Reinforcement Hardened Steel for Reinforced Concrete Constructions. Technical Specifications

GOST 12004–81 Reinforcement Steel. Tensile Tests

GOST 12423–66 Plastics. Conditioning and Sample Testing

GOST 14192–96 Cargo Marking

GOST 14359–69 Plastics.Mechanical Tests. General Requirements

GOST 15139–69 Plastics. Density (Specific Weight) Tests

GOST 15150–69 Machines, Apparatuses and Other Technical Devices.Climatic Versions. Categories, Operation, Storage and Transportation Conditions Relative to Effect of Different Environmental Factors

GOST 16504–81 System of State Tests of Products.Tests and Quality Control of Products. Main Terms and Definitions

GOST 17308–88 Binding Twines. Technical Specification

Official Release

GOST 28840–90 Machines for Tensile, Compression and Bending Tests. General Specifications
GOST 30108–94 Construction Materials and Products. Determination of Specific Effective Intensity of Natural Radionuclides
GOST 30247.0–94 Building Structures. Test for Fire Resistance. General Specifications
GOST 30403–96 Building Structures. Fire Safety Tests

Note – When using this standard please make sure to check effectiveness of reference standards of common use information system on the official website of Federal Agency for Technical Regulation and Metrology on the Internet or in annual information bulletin «National Standards» that is published as of January 1 of the current year and in monthly information bulletin «National Standards» for the current year. If a referenced standard is replaced (revised), refer to such revised edition of the standard when using this standard. If a referenced standard has been cancelled without substitute, provision referencing to such cancelled standard shall apply to such an extent as not to affect such reference.

3 Terms and Definitions

The present standard employs terms as per GOST 10884 and GOST 12004, as well as the following terms with respective definitions:

3.1 **compound**: hard product consisting of two or more materials differing from one another in shape and/or physical state and/or chemical composition and/or properties, as a rule connected by means of physical bonds and having interface between basic (matrix) material and fillers, including reinforcement fillers.

Note – Matrix and filler of the compound form a uniform structure and interact thus providing the best properties of end-product based on its intended use.

3.2 **polymer matrix**; matrix: structure consisting of cure thermal setting resin that ensures integrity of polymer composite, responsible for transfer and distribution of stresses in the reinforcement filler and that affects thermal resistance, water resistance, fire resistance and chemical stability of polymer composite.

3.3 **thermal setting resin**: resin that upon curing under the influence of temperature and/or due to chemical reaction irreversibly becomes hard, infusible and insoluble material with a 3D grid structure.

Note – Hard organic resins include non-saturated polyester, epoxide, vinylester, phenolic and other types of resins.

3.4 **Filler of thermal setting resin;** filler: material admixed with thermal setting resin prior to curing process to change or provide necessary properties to the resin and/or matrix, or to reduce price of end product.

3.5 **Reinforcement filler**: material or product added to thermal setting resin before the curing process to improve physical properties of polymer compound.

Note

1 Term «reinforcement filler» in this standard means reinforcement filler made of continuous fiber. This term is not a synonym to the term «filler».

2 To produce FPB continuous reinforcement fillers made of glass fiber, basalt fiber, carbon fiber and aramid fiber are used.

3.6 **fiber**: flexible long continuous and strong body of some length with small crosswise size relative to its length used for production of fiber-like materials intended for reinforcement of polymer compounds.

Notes

1 Crosswise size includes thickness or diameter of fiber.

2 Depending on manufacturing technique fiber can be continuous or staple.

3.7 **Glass fiber**; fiberglass: fiber for reinforcement of polymer compounds made of melted inorganic glass.
3.8 **Basalt fiber**: fiber for reinforcement of polymer compounds made of melted touchstone or gabbrodiabase.
3.9 **Carbon fiber**: fiber for reinforcement of polymer composites made by pyrolysis of organic fibers of precursors and containing at least 90% of carbon weight.

Notes
1 Precursors can, for instance, include polyacrylnytrilic fibers or regenerated cellulose fiber.
2 Depending on tensile strength and elasticity modulus carbon fibers can be divided into common-purpose fibers, high-duty, intermediate modulus, high modulus and ultrahigh modulus.

3.10 **Aramid fiber**: fiber for reinforcement of polymer composites made of linear fiber-forming polyamides in which at least 85 % of amide groups are bound with two aromatic rings.
3.11 **Glass composite**: polymer composite containing continuous reinforcement filler of fiberglass.
3.12 **Basalt composite**: polymer composite containing continuous reinforcement filler of basalt fiber.
3.13 **Carbon composite**: polymer composite containing continuous reinforcement filler of carbon fiber.
3.14 **Aramid composite**: polymer composite containing continuous reinforcement filler of aramid fiber.
3.15 **Combined composite**: glass composite or basalt composite or carbon composite or aramid composite additionally filled with reinforcement filler of other type(s) of fibers.
3.16 **Ribbed fiber-reinforced polymer bars**; polymer fiber-reinforced bars; PFB: reinforcement bar with anchor layer equally distributed on the surface and laterally to its longitudinal axis made of thermal setting resin, continuous reinforcement filler and other fillers.
3.17 **External diameter of polymer fiber-reinforced bars**; external diameter: diameter that allows to measure nominal diameter by means of direct measurement peak of periodic protrusions on reinforcement bar.
3.18 **Nominal diameter of polymer fiber-reinforced bars**; nominal diameter: diameter of round smooth bar of equal volume with the account of tolerances specified in designation of bars, and used for calculations of physical and mechanical properties and construction calculations.
3.19 **Nominal cross section of polymer fiber-reinforced bars**; nominal cross section: cross section equal in its area to cross section of round smooth bar of the same diameter.
3.20 **Tensile strength of concrete adhesion**: shear stresses at boundary of adhesion to the concrete that appear when the bar is being torn out of concrete at the moment prior to the break of adhesion boundary.
3.21 **Tensile strength at transversal section**: shear stresses that the bar is exposed to when transversal cutting force is applied.
3.22 **Ultimate service temperature**: temperature exceeding of which leads to significant deterioration of physical and mechanical properties of bars due to softening of matrix of polymer compound.
3.23 **Reinforcement bar**: continuous bearing rod of reinforcement bars determining their physical and mechanical properties.
3.24 **Anchor layer**: transversal protrusions formed by winding a layer of continuous fiber to the bearing rod necessary to enhance adhesion of bar to concrete.
3.25 **Ribbed bar pitch**: distance between the centers of two protrusions measured parallel to longitudinal axis of reinforcement bar.

4 Classification, Basic Parameters and Dimensions

4.1 Depending on type of reinforcement filler PFB can be divided into following categories:
АСК – glass composite;
АБК – basalt composite;
АУК – carbon composite;
ААК – aramid composite;
АКК – combined type.
4.2 PFB are manufactured with nominal diameters as per Table 1.

Table 1

Nominal diameter d, mm	4	6	8	10	12	14	16	18	20	22	25	28	32

Note – PFB can be produced with other nominal diameter provided compliance with this standard.

4.3 Value of external diameter of PFB shall not be less than the value specified in manufacturing specifications of the manufacturer.
4.4 PFB can have different ribbed profile ensuring necessary strength of adhesion of the bar with concrete, including after influence of corrosive media.
4.5 Documents of manufacturer for a particular type of PFB shall contain following geometric dimensions of ribbed bar with respective tolerances:
- Nominal diameter;
- External diameter;
- Ribbed bar pitch;
- Nominal cross section.

4.6 PFB are made in the form of bars with specific cut length from 0.5 to 12.0 m with the length increment of 0.5 m, bars of a larger length can also be manufactured.
4.7 Tolerances in the length of specific cut bars shall match the values set forth in Table 2.

Table 2

Bar length, m	Length tolerances, mm
Up to 6	+25
Over 6»12 »	+35
» 12	+50

4.8 PFB with nominal diameter of 4 to 8 mm can be supplied in rolls and drums.
4.9 Minimum diameter of roll or drum in $d_б$, mm, shall ensure safety of PFB under any conditions of its transportation and storage till its use and shall be calculated using formula

$$d_б \geq 2d\frac{E_f}{\sigma_в}, \quad (1)$$

whered is nominal diameter, mm;
σв tensile strength, MPa;
Ef tensile modulus MPa.
4.10 Legend of PFB shall include: legend for type of product based on type of reinforcement fiber as per 4.1, nominal diameter, value of tensile strength, value of tensile modulus and designation of the present standard.

Samples of the legend:

- fiberglass composite bars with diameter of 12 mm, tensile strength of 1000 MPa, tensile modulus of 50 GPa:

АСК-12-1000/50 –GOST 00000–2012

- combined composite bars containing continuous fillers of fiberglass and basalt fiber (reinforcement filler of fiberglass is major one, and basalt fiber is additional), with diameter of 10 mm, tensile strength of 1300 MPa, tensile modulus of 90 GPa:

АКК (СБ)-10-1300/90–GOST 00000–2012

5 Technical Requirements

5.1 Basic specifications

5.1.1 PFB shall be manufactured according to production documentation approved in accordance with the established procedure and shall comply with the requirements of this standard.

5.1.2 PFB shall be produced of thermal setting resin and shall contain continuous reinforcement filler in the amount of at least 75 % of its weight.

5.1.3 Physical and mechanical properties of PFB shall comply with those given in Table 3 below.

Table 3

Item	Specification
Tensile strength $\sigma_в$, MPa, NLT	As per Table 4
Tensile modulus E_f, GPa, NLT	As per Table 4
Compression strength $\sigma_{вс}$, MPa, NLT	As per Table 4
Cross section cut strength τ_{sh}, MPa, NLT	As per Table 4
Adhesion strength with concrete τ_rMPa, NLT	12
Reduction of tensile strength after exposure to alkaline medium $\Delta\sigma_в$, %, NMT	25
Adhesion strength with concrete after exposure to alkaline medium τ_r MPa, NLT	10
Ultimate service temperature $T_э$, °C, NLT	60

5.1.4 Physical and mechanical properties of PFB for different types shall comply with those set forth in Table 4 below.

Table 4

Item	АСК	АБК	АУК	ААК	АКК
Tensile strength $\sigma_в$, MPa, NLT	800	800	1400	1400	1000
Tensile modulus E_f, GPa, NLT	50	50	130	70	100
Compression strength $\sigma_{вс}$, MPa, NLT	300	300	300	300	300
Cross section cut strength τ_{sh}, MPa, NLT	150	150	350	190	190

5.1.5 Tensile strength and tensile modulus of PFB shall not be lower than the values set forth in manufacturer's documents. If manufacturer's documents give higher values for tensile strength and tensile modulus these values should be referred to.

5.1.6 Climate variant PFB – УХЛ2 as per GOST 15150.

5.2 Appearance

5.2.1 Identification attributes of PFB characterizing trademark, geometric properties and specifications of ribbed profile bar shall be set forth in manufacturer's documents.

5.2.2 Appearance (shortcomings) of PFB shall comply with the requirements set forth in Table 5 5.

Table 5

Defect	Specified limit
Chips	Not allowed
Segregation	Not allowed
Caverns	Not allowed
Scratch with breaking of winding	Not allowed
Mechanical impact dents with fiber damage	Not allowed

5.3 Requirements for raw and other materials

5.3.1 Materials used for production of PFB shall comply with the requirements of regulatory and technical documents, and have accompanying documents, certifying their compliance with the requirements of such regulatory and technical documents, including test reports.

5.4 Marking

5.4.1 Product package shall contain clearly readable marking.

5.4.2 Marking is done by means of labeling.

5.4.3 Marking is applied by printing.

5.4.4 Each package shall have label attached. Method and place of label attachment shall be specified in manufacturer's documents.

5.4.5 Location of label shall ensure unambiguous visual identification of products without breaking the package.

5.4.6 Marking shall retain for the entire shelf life during storage, transportation and handling operations.

5.4.7 Marking of PFB shall contain following items:

- name;
- country of origin;
- manufacturer's name;
- legal address of manufacturer;
- trademark of manufacturer;
- main application properties and/or specifications;
- certification data;
- batch number and manufacture date;
- composition (completeness);
- legend;
- number of items per package;
- total length per package;
- stamp of QCD supervisor and signature of packing operator;

-designation of the standard and/or specifications used for production and identification of the product;

- bar code;
- transport marking as per GOST 14192 with manipulation sign «Keep Dry!»

Note – When marking PFB regulations of the legislation of each Member Country shall be complied with regard to marking the products with information using national language.

5.5 Packing

5.5.1 Package shall ensure safety of PFB during handling operations, transportation and storage.

5.5.2 PFB of one batch of specific cut length are packed in sheaves, or upon customer's consent to rolls and drums as per 4.8.

5.5.3 PFB of specific cut length shall be tightly stacked and bound transversely at 1–1.5 m intervals, in which case distance from end point binding to the end point of bars shall be 10–20 cm.

5.5.4 Roll shall be bound by two diametrical cords, while several rolls shall be bound by two or three cords.
5.5.5 Binding is done using binding twines as per GOST 17308 or bands as per GOST 3560.
5.5.6 For manual handling weight of a sheave, roll or drum, as well as non-packed PFBs shall not exceed 80 kg.
5.5.7 When machine handling is used weight of sheave, roll or drum is governed by the type and technical specifications of lifting equipment of manufacturer and customers. Manual handling shall be specified in order.

6 Safety Requirements and Environmental Protection

6.1 Under normal use, transportation and storage conditions as per Section 9 PFB shall not emit toxic or hazardous substances in concentrations that may harm human health or environment.
6.2 Hygienic requirements [1] for PFB are set forth in Table 6.
6.3 Production of PFB shall be performed according to [2] and [3].
6.4 Control of hazardous manufacturing factors during production and hygienic properties of end products shall be exercised according to the program for production control approved at the manufacturing facility as per [4] and [5].
6.5 When using PFB requirements of GOST 17.2.3.02 for environmental protection are to be met.

Table 6

Item	Value
Odor level, nmt	2 points
Volatile matter concentration in air as per [6], nmt: - phenol - formaldehyde - toluol	 0,003 mg/m^3 0,003 mg/m^3 0,600 mg/m^3
Effective specific intensity of natural radionuclides $A_{эфф}$ as per [7], nmt	370 Bq/kg

Effective specific intensity of natural radionuclides Аэфф as per [7], nmt 370 Bq/kg
6.6 Disposal of PFB wastes shall be performed according to effective legislation governing environmental protection. Safety and protection requirements for environmental control shall be set forth in manufacturer's documents.
6.7 Manufacturer's documents shall specify codes of explosive and fire hazard rates as per GOST 12.1.044 that shall be taken into account for selection of transportation and storage conditions.

7 Acceptance Rules

7.1 PFB shall be accepted in batches according to the requirements of this standard. Batch shall contain PFB of the same composition and standard size, made of materials of the same brand, using same regulatory documents, the same production line, with allowed process stops for not more than 3 hours. Amount of batch shall be set out in regulatory documents of manufacturing facility.
7.2 Each batch of PFB shall be accompanied by certificate (see Annex И).
7.3 PFB shall be accepted by quality by QC Department of manufacturing facility, and the following types of operating control shall be exercised as per GOST 16504:
- incoming control – quality of raw materials used for production of PFB, their conformity with regulatory documents used for release of such materials, and compliance with technical regulation;

- operating control – parameters of equipment operation and functioning of manufacturing process for PFB and their compliance with technical regulation;
- acceptance control – number and properties of quality of PFB set forth herein.

7.4 To ensure compliance of PFB with the requirements of this standard following tests shall be performed as per GOST 16504:
- user acceptance testing;
- periodical testing;
- type testing.

7.5 User acceptance testing is performed for each batch.

7.6 Periodical testing is performed once every 6 months of the date of the original periodical testing (for the first year of testing) or once a year of the date of previous testing (for the following production years). To perform periodical tests PFB samples are taken from batches that meet the requirements of this standard based on the results of manufacturing control and user acceptance testing.

7.7 Results of periodical testing apply to all PFB batches manufactured within the period between two regular periodical testing.

7.8 Results of user acceptance testing and periodical testing for PFB shall be included to the certificate.

7.9 Type tests are performed:
- In case of alteration of raw materials;
- In case of amendment to regulatory documents for any raw material;
- In case of modification of production process;
- Upon customer's request and during certification.

7.10 Extent of tests of each type is given in Table 7.

7.11……Qualification tests are performed during manufacture of PFB at a new facility or using new equipment for all parameters set forth in Table 7 using at least three first batches.

7.12 When test results failed for any of tested parameters retests for such parameters shall be performed using doubled number of samples. In case the retest also fails the batch is rejected, production of PFB is stopped, analysis is performed as to discover the causes of failure, and plan is drawn up for measures to be taken in order to eliminate such causes; test batch is being produced and used for complete set of user acceptance and periodical testing of the parameters that failed original tests. Should the results of testing such test batch be successful, product manufacture is resumed. In case of non-satisfactory results of testing of such test batch causes of defect are being analyzed until test results compliant with the requirements hereof are obtained.

7.13 Manufacturer of PFB shall warranty the conformity with the requirements set forth in p. 5.1.3–5.1.4 with confidence level of at least 95 % and annual confirmation of conformity with these requirements based on statistical analysis of results of such user acceptance and periodical testing, obtained for the entire period of production.

Table 7

Parameter tested	Test type			Sample quantity
	user acceptance	periodical	type test	
Appearance	+	–	+	NLT 10 %
Dimensions: - external diameter d_n - nominal diameter d - length l	 + + +	 – – –	 + + +	NLT 3 pcs. for use acceptance, NLT 6 pcs. for periodical and type testing
Tensile strength $\sigma_в$	+	–	+	

Ending of Table 7

Tested Parameter	Type of testing			
	User acceptance	periodical	Type test	Sample volume
Tensile modulus E_f	+	–	+	NLT 3 pcs. For user acceptance test and NLT 6 pcs. For periodical and type tests
Compression strength $\sigma_{вс}$	–	+	+	
Cross section cut strength τ_{sh}	–	+	+	
Adhesion strength with concrete τ_r	–	+	+	
Reduction of tensile strength after exposure to alkaline medium $\Delta\sigma_в$,	–	+	+	
Adhesion strength with concrete after exposure to alkaline medium τ_r	–	+	+	
Ultimate service temperature $T_э$,	–	+	+	

7.14 When assessing stability of production compliance of PFB parameters with the required values is determined based on the results obtained within the period that does not exceed 6 months. Compliance criteria of PFB parameters with required values during production stability assessment are given in Table 8.

7.15 Compliance of PFB with required parameters is determined by means of calculation of number of results obtained during assessment period that are beyond required values and comparison of such number with acceptance number.

7.16 Compliance of PFB with actual required value is confirmed if the number of results beyond required values does not exceed the acceptance number.

Table 8

Number of tests	Acceptance value
1–6	1
13–19	2
20–29	3
30–39	4
40–49	5
50–64	6
65–79	7
80–94	8
95–100	10

8 Control Methods

8.1 Appearance and quality of surface of PFB is inspected for compliance with established specifications and reference sample visually without magnifying glasses.

8.2 External diameter, height of ribbed profile bar, ribbed bar pitch of PFB are measured using caliper as per GOST 166, and micrometer as per GOST 6507.

8.3 Length of PFB is measured with the ruler as per 427, measuring tape as per GOST 7502 with nominal scale length of 10, 20 m of class III precision.

8.4 Nominal diameter is measured as per GOST 15139 with annexes (see Annex A).

8.5 Mechanical properties during axial tensile are determined according to GOST 12004 and its amendments (see Annex Б).

8.6 Compression strength is determined as per GOST 4651 with amendments and annexes (see Annex B).
8.7 Cross section cut strength is determined as per Annex Г.
8.8 Adhesion strength with concrete is determined as per Annex Д.
8.9 Resistance of concrete to alkaline medium is determined ass per Annex E.
8.10 Ultimate service temperature is determined as per Annex Ж.
8.11 Specific effective intensiveness of natural radionuclides in raw materials for PFB production is determined as per GOST 30108.

9 Transportation and Storage

9.1 PFB is transported horizontally by any transport mode according to transportation regulations for cargo applicable to respective transport mode with adherence to storage conditions.
9.2 PFB shall be stored horizontally on the racks in unheated or heated warehouses not closer than 1 m from heating appliances at 100 mm above floor level.
9.3 When storing, transporting and handling products make sure to avoid physical damage to PFB, exposure to UV light and moisture.

10 Manufacturer’s Warranty

10.1 Manufacturing facility shall warranty product quality as per requirements of this standard provided that customer complies rules and conditions of storage, transportation and use.
10.2 Warranty period of PFB shall be 24 months of the date of manufacture.
10.3 Upon expiration of warranty shelf life PFB can only be used for intended purpose after their inspection for complete compliance with the requirements of this standard.

Annex A
(for reference)

Measuring Nominal Diameter

A.1 General Provisions

This method is based on determination (based on the results of hydrostatic weighing) of volume of a specific cut length samples of tested product followed by calculation of nominal diameter.

A.2 Samples

A.2.1 Samples are randomly taken from tested batch of PFB and accompanied by the reports of sampling where following data shall be indicated:

- Name of manufacturer;
- legend;
- type of fiber and bounding agent;
- manufacture date;
- batch number;
- number and size of samples;
- parameters to be tested;
- signature of person in charge of sample.

A.2.2 When taking and preparing samples of PFB for tests avoid deformation and heating, exposure to UV light or other environmental factors that may result in change of properties of the material.

A.2.3 Number of samples for tests shall be based on data from Table 7.

A.2.4 Specific cut length pieces of 1 mm in length that is calculated using formula below are used as samples

$$l \geq 10 l_{np}, \quad \text{(A.1)}$$

where l is pitch length of ribbed profile, mm.

A.2.5 Test samples shall be prepared as per GOST 12423.

A.3 Apparatus and Materials

To perform test the following apparatus and material will be required:

- analytical balances of at least precision class II;
- vessel and accessories (clamps) for hydrostatic weighing for analytical balances;
- caliper as per GOST 166 with max 0.1 mm increment.

A.4 Testing

A.4.1 Test conditions shall comply with Subsection 3.15 of GOST 15150.

A.4.2 Length of each sample is measured three times rotating it by 120° after each measurement. Mean value of three measurements is rounded to 0.1 mm. Measurement tolerance for length shall not exceed 0.1 mm.

A.4.3 Pour distilled water that has been exposed to ambient room temperature for 2 hours before the test to vessel for hydrostatic weighing.

A.4.4 Submerge a clamp without sample to water, reset or record readings of balances.

A.4.5 Grip the sample to the clamp and record readings of balances m1, and then submerge sample in the clamp to water and record readings of balances m2.

A.5 Result Interpretation

Nominal diameter is calculated using following formula

$$d = \sqrt{\frac{4(m_1 - m_2)}{\pi \rho l}}, \quad \text{(A.2)}$$

where m1 is weight of sample in the air, mg;
m2 is weight of sample in water, mg;
p is water density, mg/mm3 (usually p = 1);
l is length of sample, mm.

Values of tested parameter and values used in intermediate calculations should be determined with relative tolerance of not more than 0.01 (1 %).

Statistical analysis of the results is performed as per GOST 8.207.

A.6 Test Report

Test Report shall include:

- data about samples given in sampling report;
- name of organization performing tests;
- date of test;
- information about conditions under which test was performed;
- values for measured parameters for each sample;
- values for tested parameters of each sample obtained during result evaluation;
- mean values, standard deviation of tested parameters and results of statistical analysis of results obtained;
- information on staff performing tests and their signatures.

Annex B
(for reference)

Test for Axial Tension

Б.1 General Provisions

This test method defines requirements for test for axial tension of PFB to determine following properties:

- strength;
- elasticity modulus;
- relative extension.

Method describes following requirements for testing procedure for axial tension of PFB:

- break of test sample shall take place within specific area;
- specific area here means the area of the sample between test clamps used for gripping the samples with the grips of testing machine;
- influence of tangent and radial tensile modulus appearing in transient zone between test grip and rod on breaking process is not taken into account.

Б.2 Samples

Б.2.1 Samples are randomly taken from tested PFB batch and accompanied with sampling report containing following information:

- Name of manufacturer;
- legend;
- type of fiber and bounding agent;
- manufacture date;
- batch number;
- number and size of samples;
- parameters to be tested;
- signature of person in charge of sample.

When taking and preparing samples of PFB for tests avoid deformation and heating, exposure to UV light or other environmental factors that may result in change of properties of the material.

Number of samples for tests shall be based on data from Table 7.

Б.2.2 Length of testing grips shall be selected so that sample breaking appeared within specific area without slipping effect.

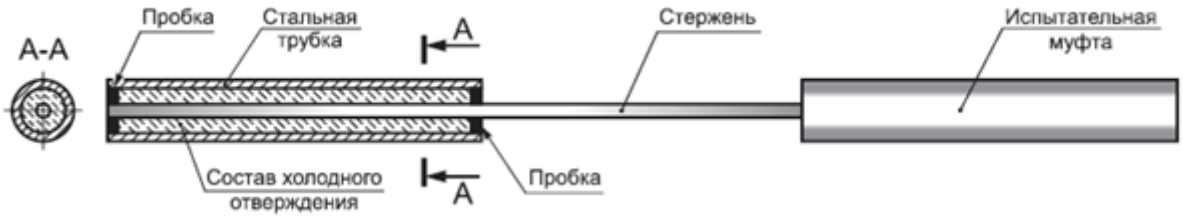
Б.2.3 Length of test sample is determined by the length of specific area and two test grips.

Recommended design of test grip for test is given in Figure Б.1, Table Б.1.

Length of specific area shall be at least 40d of the bar.

Б.2.4 Shorter samples can also be used provided that breaking appears within specific area without slipping in grips.

Б.2.5 Test samples shall be conditioned as per GOST 12423 prior to testing.



Пробка-plug, стальнаятрубка-steel tube, составхолодногоотверждения – cold cure compound, стержень - rod, испытательнаямуфта – test coupling

Figure Б.1 – Typical Testing Device

Table Б.1– Dimensions of test samples and test grips, mm

PFB Nominal diameter	Test Grip		
	External diameter	Minimum length	Wall thickness
From 4 to 10	35	300	From 3 to 5
»12 »16	42	350	
»18 »22	48	450	

Б.3 Apparatus and Materials

Б.3.1 Testing machine as per GOST 28840 ensuring:

- stress exceeding sample strength during test for tested parameter;
- measurement of stress and distance between two members with tolerance of NMT 0.5 %;
- moving rate of movable member within 5 to 100 mm/min.

Б.3.2 Data recorder shall ensure continuous record of stress, deformation and movement. Minimum recordable value shall be:

- for stress 100N;
- for strain 0.01 mm;
- for movements 0.001 mm.

Б.3.3 Extension meters and linear movement sensors are used as tension meters that shall ensure record of sample extension during test with the precision of NLT 0.002 % for the length of sample between sensors.

Б.4 Testing

Б.4.1 Test conditions shall comply with subsection 3.15 of GOST 15150.

Б.4.2 When putting sample to testing machine make sure that longitudinal axis of sample is aligned with attachment line to grips.

Б.4.3 Extension meter or linear movement sensors shall be installed at a distance of grips of at least 8d of bar, while length of base for measurement of longitudinal deformation shall be at least 8d of the bar.

Б.4.4 Estimated maximum stress P, N, is determined based on the results of testing the sample.

Б.4.5 Data recorder shall be activated several second prior to application of stress. Stress application speed shall be constant during the test and shall ensure sample breaking within 3 to 10 minute period.

Б.4.6 Deformation should be recorded till the stress levels of at least 50 % of tensile strength.

If sample is broken in grip or slips out of it, addition test shall be performed for the sample of the same batch.

Stress-strain graph shall be plotted based on the readings of stress and strain recorded by extension meter.

Б.5 Result Interpretation

Б.5.1 Strength σвMPa, is calculated using following formula

$$\sigma_в = \frac{P}{A}, \qquad (Б.1)$$

whereP is collapse stress, N;

A is cross section area of bar A = πd 2/4, mm2.

Б.5.2 Value of initial tensile modulus Ef, MPa, is calculated as ratio of stress increments during extension within the interval of 0.2P to 0.5P and strains according to following formula

$$E_f = \frac{P_1 - P_2}{(\varepsilon_1 - \varepsilon_2)A}, \qquad (Б.2)$$

where P1 is stress, making (50 + 2) % of collapse stress, N;

P2 is stress, making (20 + 2) % of collapse stress, N;

ε1 is strain, matching stress P1;

ε1 is strain, matching stress P2.

Б.5.3 Relative extension $\varepsilon_в$ mm/mm, at collapse stress is calculated using following formula

$$\varepsilon_в = \frac{P}{E_f A}. \quad (Б.3)$$

Values of test parameters and other values are determined with precision of up to 0.001.
Statistical analysis of test results is performed according to GOST 8.207.

Б.6 Test Report

Test Report shall include following data:

- information about samples given in sampling report;
- name of organization performing tests;
- date of testing;
- information about conditions under which test is performed;
- geometrical parameters of each sample;
- values of measured parameters for each sample;
- values of tested parameters of each sample obtained during test;
- mean values of tested parameters and results of statistical analysis of test results obtained;
- stress-strain graph per each sample;
- information about staff performing tests and their signatures.

Annex B
(for reference)

Compression Test

B.1 General Provisions

This method defines requirements to testing PFB for compression to identify strength limit.
The method is based on sample breaking by application of compressing axial stress. The method accounts for general provisions of GOST 4651 and its amendments:

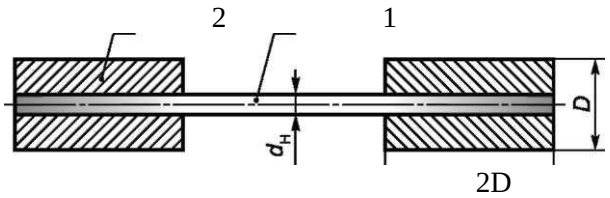
- Test sample breaking shall take place within specific area;
- Specific area is an area between two grips;
- influence of tangent and radial tensile modulus appearing in transient zone between test grip and rod on breaking process is not taken into account.

B.2 Samples

B.2.1 Samples are randomly taken from tested PFB batch and accompanied with sampling report containing following information:

- Name of manufacturer;
- legend;
- type of fiber and bounding agent;
- manufacture date;
- batch number;
- number and size of samples;
- parameters to be tested;

signature of person in charge of sample.
When taking and preparing samples of PFB for tests avoid deformation and heating, exposure to UV light or other environmental factors that may result in change of properties of the material.
Number of samples for tests shall be based on data from Table 7.
B.2.2 Test sample (see figure B.1) consists of part of bar, to the ends of which test grips are glued.



1 –piece of bar; 2 – test grip
Figure B.1 – Testing Diagram

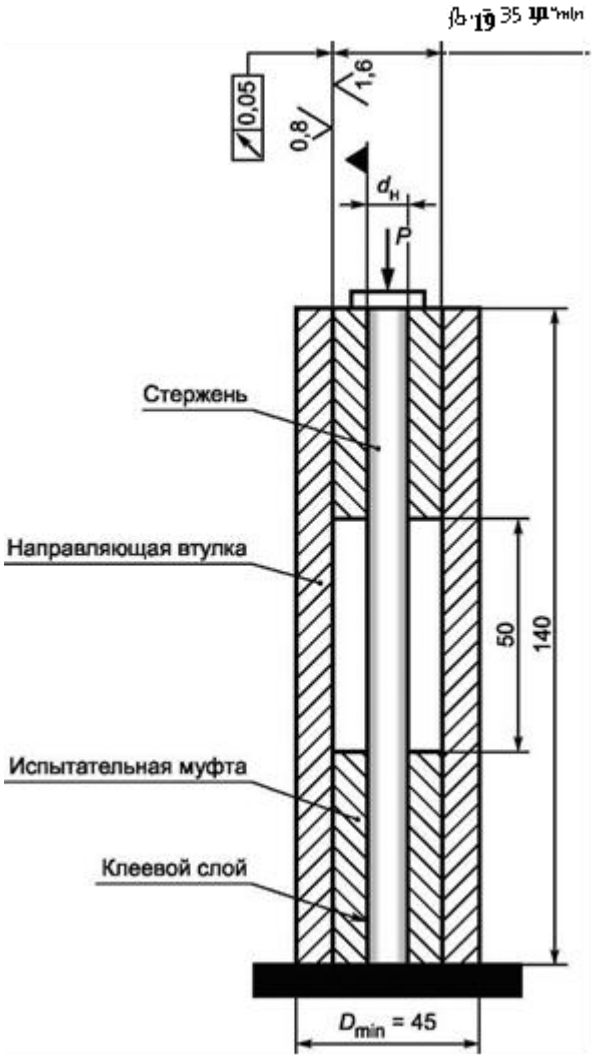
B.2.3 Total length of sample depends on the design of inserts.
B.2.4 Length of specific area of the bar located between the inserts shall be 6d.
B.2.5 Test samples shall be conditioned as per GOST 12423 prior to testing.

B.3 Apparatus and Materials

B.3.1 Testing machine as per GOST 28840 shall ensure:

- Stress exceeding sample strength during test for tested parameter;
- Measurement of stress and distance between two members with tolerance of no more than 0.5 %;
- Movement speed of movable member within 5 to 100 mm/min.

B.3.2 Test device for sample compression (see Figure B.2) consists of guiding insert, making it possible to apply stress straight along the bar axis, and two test grips, installed at the ends and ensuring sample breaking within specific area.



Стержень - rod, направляющаявтулка – guide sleeve, испытательнаямуфта – test coupling, клеевойслой – adhesive layer

Figure B.2 – Test device for Compression Testing

B.4 Testing

B.4.1 Testing conditions shall comply with section 3.15 of GOST 15150.

B.4.2 Sample shall be installed to testing device.

B.4.3 Measuring system is switched on and drive of testing device is switched to testing mode. Recommended speed is 5 to 15 mm/min. Stress shall be applied gradually without hitting the sample.

B.4.4 Stress application shall be done until sample breaks. Should sample break beyond specific area, additional test of sample of the same batch is to be performed.

B.4.5 Collapse stress shall be determined with the tolerance of up to 0.001.

B.5 Result Interpretation

Strength σвс, MPa, is calculated using following formula

$$\sigma_{вс} = \frac{4P}{\pi d^2},$$

where P is collapse stress, N;

d is nominal diameter, mm.

Values of tested parameter and other values are to be measured with tolerance of up to 0.001. Statistical analysis of results is to be performed according to GOST 8.207.

B.6 Test Report

Test Report shall include following information:

- information about samples given in sampling report;
- name of organization performing tests;
- date of testing;
- information about conditions under which test is performed;
- test results;
- values of measured parameters for each sample;
- values of tested parameters of each sample obtained during test;
- mean values of tested parameters and results of statistical analysis of test results obtained;
- information about staff performing tests and their signature.

Annex Г
(for reference)

Cross Section Test Method

Г.1 General Provisions

This method describes requirements for testing PFB for limit strain during cross section of fibers.
Method is based on stress of sample by application of cutting force through direct application of double cut.

Г.2 Samples

Г.2.1 Samples are randomly taken from tested PFB batch and accompanied with sampling report containing following information:

- Name of manufacturer;
- legend;
- type of fiber and bounding agent;
- manufacture date;
- batch number;
- number and size of samples;
- parameters to be tested;
- signature of person in charge of sample.

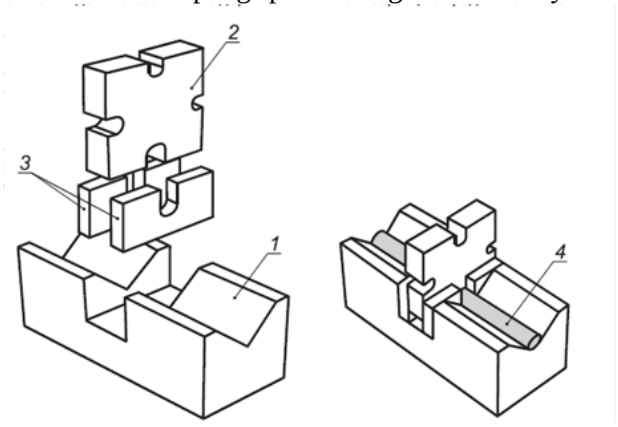
When taking and preparing samples of PFB for tests avoid deformation and heating, exposure to UV light or other environmental factors that may result in change of properties of the material.
Number of samples for tests shall be based on data from Table 7.
Г.2.2 Test sample is a bar length of which is based on the design of testing device, but shall at least be 250 mm irrespective of diameter.
Г.2.3 Test samples shall be conditioned as per GOST 12423 prior to testing.

Г.3 Apparatus and Materials

Г.3.1 Testing machine as per GOST 28840 shall ensure:

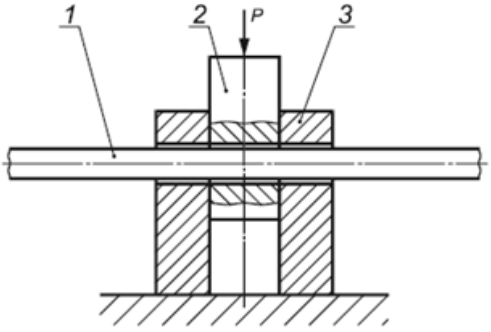
- stress exceeding sample strength during testing for respective parameter;
- measurement of stress and distance between two members with tolerance of not more than 0.5 %;
- movement speed of movable member of 5 to 100 mm/min.

rectangular dent for fixing of upper and lower blades with U-style dents or pass holes (see Figure Г.2) for samples, calibrated for their diameter.
Г.3.3 Sum of two distances between one upper and two lower blades shall be at least 0.25 mm.
1 –grip; 2 – upper blade; 3 – lower blades; 4 – sample
Figure Г.1 – Testing device of cross section
Г.3.2 Testing device shall consist of test sample grip with longitudinal V-style dent (see Figure Г.1),



1 –grip; 2 – upper blade; 3 – lower blades; 4 – sample
a) by components b) assembled
Figure Г.1 – Testing device of cross section

rectangular dent for fixing of upper and lower blades with U-style dents or pass holes (see Figure Г.2) for samples, calibrated for their diameter.
Г.3.3 Sum of two distances between one upper and two lower blades shall be at least 0.25 mm.



1- test sample; *2* – upper blade; *3* – lower blade

Figure Г.2 – Device with pass holes

Г.4 Testing

Г.4.1 Testing conditions shall comply with subsection 3.15 of GOST 15150.

Г.4.2 Sample is inserted to the testing device and installed to testing machine.

Г.4.3 Surface of the upper blade is in contact with stressing device of testing machine, and there shall be no gap.

Г.4.4 Measuring system is switched on and drive of testing machine is switched to testing mode. Rate of increase of tangent motions shall be of 5 to 15 mm/min. Stress shall be applied gradually avoiding hits to the samples.

Г.4.5 Sample shall be cut by edges of blades simultaneously in two planes, coming to each other along two ends perpendicular to the sample's axis.

Г.4.6 To reduce blade surface friction they can be machined, finished and coated with a thin layer of lubricant.

Г.4.7 Stress shall be applied until the sample breaks.

Г.4.8 Collapse stress shall be determined with the tolerance of up to 0.001.

Г.4.9 During the test using sensor of movement of plates of hydraulic press vertical movement of bar is measured with the tolerance of up to 0.01 мм.

Г.5 Result Interpretation

Limit cross section stress Tsh, MPa, is calculated using formula below

$$\tau_{sh} = \frac{P}{2A}, \quad (Г.1)$$

where P is collapse stress, N;

A is cross section area of sample, A = πd2/4, mm2.

Statistical analysis of the results shall be performed as per GOST 8.207.

Г.6 Test Report

Test Report shall include following information:

- information about samples given in sampling report;
- name of organization performing tests;
- date of testing;
- information about conditions under which test is performed;
- geometric properties of each sample;
- test results;
- values of measured parameters for each sample;
- values of tested parameters of each sample obtained during test;
- mean values of tested parameters and results of statistical analysis of test results obtained;
- type and nature of break of each sample;
- information about staff performing tests and their signature.

Annex Д
(for reference)

Test for Adhesion strength with concrete

Д.1 General Provisions

This method describes requirements for test for adhesion strength between PFB and concrete by means of axial pulling out of cube or bar testing for bending.

Method is based on determination of shear stress values on the border of PFB adhesion to the concrete that apply during max stress obtained during sample extension until it breaks, irrespective of where the sample broke (either the core or boundary of adhesion to concrete).

Д.2 Samples

Д.2.1 Samples are randomly taken from tested PFB batch and accompanied with sampling report containing following information:

- Name of manufacturer;
- legend;
- type of fiber and bounding agent;
- manufacture date;
- batch number;
- number and size of samples;
- parameters to be tested;
- signature of person in charge of sample.

When taking and preparing samples of PFB for tests avoid deformation and heating, exposure to UV light or other environmental factors that may result in change of properties of the material.

Number of samples for tests shall be based on data from Table 7.

Д.2.2 Test samples for axial pulling consist of concrete cubes, in the center of which PFB bar is inserted vertically with test grip perpendicular and parallel to concrete layering (see Figure Д.1). Size of concrete cubes depends on PFB diameter and is set in Table Д.1.

Total length of test sample depends on the following:

- conditions of insertion to concrete;
- conditions of installation of sample to testing machine;
- test grip design.

Table Д.1 – Dimensions of test samples, mm

Nominal diameter of PFB	Size of concrete cube edge	Length of adhesion of PFB to concrete
< 10	100	5d
from 12 to 18	150	
» 20 »30	200	

Д.2.3 The bar beyond the concrete shall be protected by PVC insert or tube.

Д.2.4 Surface of sample with vertical bar should be covered with square steel plate of at 200x200 mm in size and 20 mm in thickness, that is used as bearing surface for test and eliminates force application to concrete cube. There shall be a hole in the center of the plate for bar.

Д.2.5 Test samples for bar bending (see Figure Д.2) consist of two halves attached to one another in extended area by tested PFB bar, and in closed area with hinge in the form of two insert pieces and steel cylinder between them. PFB in the middle of each half has adhesion area with concrete equal to 10d, while the part of it beyond the concrete is in PVC tube.

Test samples should have rectangular cross section of 120 x 220 mm, length of 1230 mm, halves length of 600 mm, gap between the halves of 30 mm. Distance from the axis of test bar to the axis of steel cylinder in closed area should be 167 mm.

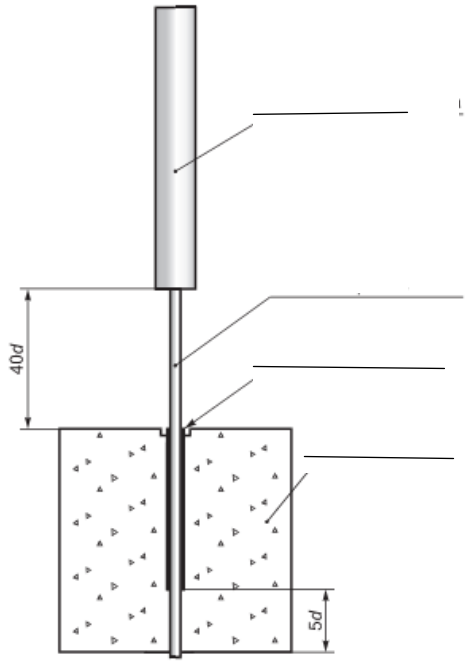
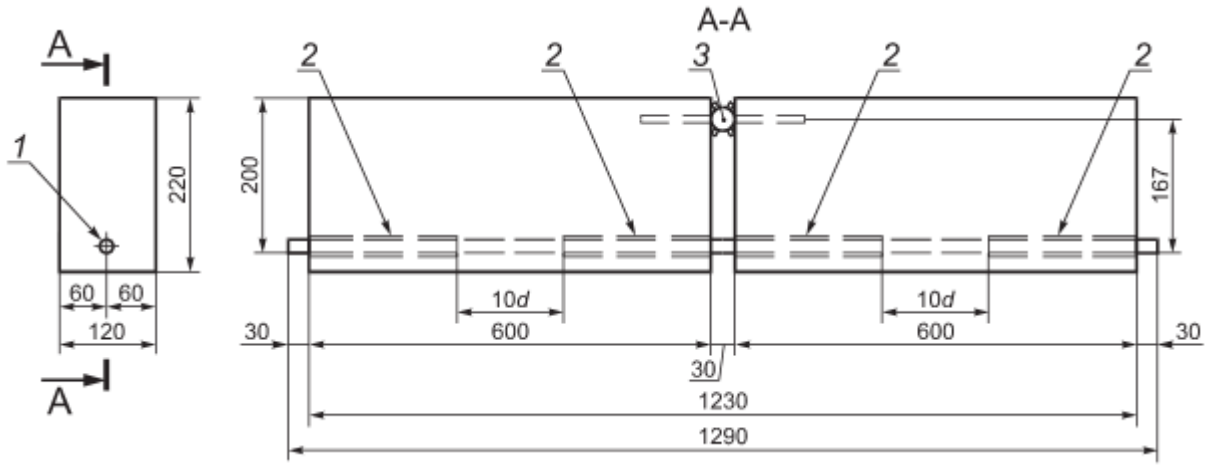


Fig. Д.1 – Setting PFB into a concrete cube



1 – *rod;* 2 – *PVC insert or tube;* 3 – *steel cylinder*

Fig. Д.2 – Setting PFB into concrete when subjecting a beam to a bend test

Д.2.6 The following method of concrete forming is recommended:
- The concrete mix is placed in four layers of roughly the same thickness and each layer is poked 25 times with a metal rod of 16 mm diameter;
- After the upper layer has been compacted, the surface is smoothened and protected from moisture evaporation, also including the zone of contact of the vertically set rod with concrete.

Д.2.7 The concrete shall meet the following requirements:
- Filler size 20–25 mm;
- Plasticity grade of concrete mix П3;
- Concrete class as per compression strength B25.

Д.2.8 Concrete compression strength is determined using no less than 3 cubes with an edge dimension of 100 mm. The sample formwork shall be stripped no earlier than 24 hours after having been made. Samples are stored in normal conditions. The age of samples being testing shall be 28 days.

Д.2.9 Prior to being tested, the test samples shall be cured to GOST 12423 requirements.

Д.3 Test equipment and materials

Д.3.1 The test machine as per GOST 28840 shall ensure the following:

- A stress exceeding sample strength when testing for the controlled parameter;
- Measuring the stress and the distance between traverses with a maximum error of 0.5 %;
- Speed of travel of active traverse within 5 to 100 mm/min.

Д.3.2 To measure PFB slip in concrete, the following instruments are used: strain gauges, linear displacement transducers, analog or digital indicators with reading accuracy to 0.01 mm (slip meters).

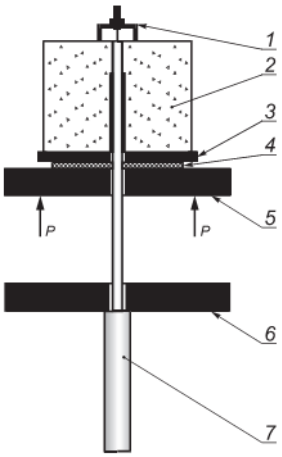
Д.3.3 To make test samples the following is needed:

- metal forms for making concrete cubes and beams with holes for setting an PFB rod of required diameter, which should be water resistant and easily disassembled without damaging the rods;
- test couplings as per Table Б.1 Annex Б.

Д.4 Test procedure

Д.4.1 Test conditions shall comply with subsection 3.15 GOST 15150.

Д.4.2 The sample for testing by axial pulling from the cube is placed so that the bearing plate of the concrete cube, wherefrom the free end of the rod extends, shall be in contact via a soft padding with the movable traverse of the test machine (see Fig. Д.3)



1 – slip meter on rod free end; *2* – sample; *3* – bearing plate; *4* – soft padding; *5* – movable traverse of test machine;
6 – fixed traverse of test machine; *7* – test coupling

Fig. Д.3 – Sample testing with axial pulling out from cube

Д.4.3 The bearing block shall rest on a support, which transmits the response to the test machine strain measurement device.

Д.4.4 The extending rod shall pass through the bearing block assembly and bearing plate, whereas the test coupling shall be mounted via the fixed traverse or in test machine clamps.

Д.4.5 The slip meter shall be placed on the rod free end.

Д.4.6 The distance between the upper surface of the fixed traverse or of the test machine clamps to the surface where the slip meter is installed shall be measured to ±0.01 mm.

Д.4.7 If the rod has ruptured or slipped in the test coupling earlier than it has slipped in concrete, or if owing to concrete cracking the applied stress has decreased significantly, measurement data are rejected, and tests are repeated on an additional sample taken from the same batch.

Д.4.8 If during tests concrete has undergone cleavage, the size of the concrete cube edge has to be increased or beams should be used for testing.

Д.4.9 Beam bend tests are conducted as per the diagram in Fig. Д.4. Slip meters are installed on beam ends and on the rod end.

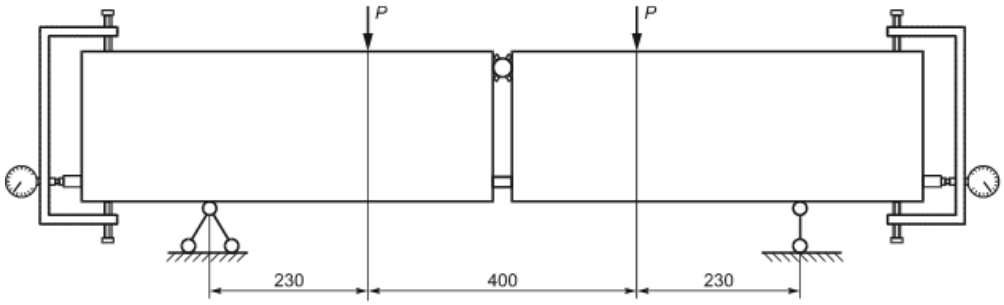


Fig. Д.4 – Sample beam bending test

Д.4.10 The applied stress shall be recorded and the slip meter readings are taken at an equal interval of 10 % of the expected stress of rod slipping by 0.25 mm. At each stress step, the test samples are held for 15 s, and slip meter readings are taken at the same time. Then the sample is stressed to rod rupture or concrete disintegration, or rod slipping by 2.5 mm, and the stress and slip value are registered within ± 0.01 mm.

Д.4.11 The sample stress rate shall be within 20 kN/min.

Д.5 Results Interpretation

Д.5.1 The 'adhesion stress – slip' diagrams are built for each sample.

Д.5.2 The average adhesion stresses are determined, which cause slipping of rod free end by 0.05; 0.10 and 0.25 mm and yield a maximum adhesion stress.

Д.5.3 The concrete adhesion stress τ_r, MPa, for tests with axial pulling out from concrete is calculated with formula

$$\tau_r = \frac{P}{cL_{fb}}, \qquad (Д.1)$$

where$P$ is applied stress, N;

$c$is nominal rod circumference, $c = \pi d$, mm;

$L_{fb}$is length of embedding rod into concrete, mm.

Д.5.4 At each step of applied stress the slip value at the rod free end is calculated as the difference of readings of the slip meter and the rod elastic elongation.

Д.5.5 Elastic elongation S, mm, is found from formula

$$S = \frac{PL}{E_f A}, \qquad (Д.2)$$

where$P$ is stress, N;

L is length from upper surface of fixed traverse or test machine clamps to place of installing slip meter on rod free end, mm;

E_f is elasticity modulus, MPa;

A is cross-section area, $A = \pi d^2/4$, mm^2.

Д.5.6 The concrete adhesion stress τ_r, MPa, for testing beam bending is calculated with formula

$$\tau_r = \frac{N_x}{A - z}. \qquad (Д.3)$$

Д.5.7 The rod axial strain N_x, N, in the beam midsection is calculated with formula

$$N_x = \frac{M}{z}, \qquad (Д.4)$$

where$M$ is total moment in section dividing the beam in halves, N·mm;

$z$is arm of inner couple in the section dividing the beam in halves, equal to the distance from the rod axis to the steel cylinder axis in the compressed zone, mm.

Д.6 Test report

The test report shall include the following:

- Information about samples given in the sample selection report;
- Name of testing organisation;
- Test date;
- Information about test conditions;
- Geometric characteristics of each sample;
- Information about the concrete: composition and concrete mix consistency, compression strength of concrete samples at concrete age of 28 days;
- Information about rods given in sample test selection report: ultimate tensile strength and elasticity modulus, dimensions of test samples, rod length in contact with concrete;
- Values of measured characteristics for each test sample;
- Values of characteristics of each sample obtained during treatment of test results;
- Average values of characteristics and results of statistical treatment of obtained data;
- Kind of destruction, 'adhesion stress – slip' diagram for each sample; and
- Information about specialists who conducted tests and their signatures.

Annex E
(for reference)

Method of accelerated determination of alkali stability

E.1 General provisions

This test method defines the requirements to evaluating АКП alkali stability by dipping samples into an alkali aqueous solution and external action of an alkali medium on rods with subsequent tensile testing and determining the ultimate strength of adhesion with concrete.

E.2 Substance of method

The method provides for testing to two schemes:

- Scheme A – a system, at which samples are dipped into an alkali solution with subsequent elongation until complete failure. Controlled parameters – pH, alkali solution temperature, and hold time;
- Scheme B – a system, at which samples, one end of which is fitted with a test coupling for fastening it in the test machine, and the other end in the alkali solution is coupled with concrete, with subsequent pulling out from concrete.

Controlled parameters – pH, alkali solution temperature, and hold time.

E.3 Samples

E.3.1 Test samples are selected randomly from the controlled АКП batch and are obligatory accompanied with a sample selection report indicating the following:

- Name of manufacturer;
- Conventional designation;
- Type of fibre and bonding substance;
- Manufacture date;
- Batch No.;
- Number and dimensions of samples;
- Indicators, for checking of which samples were selected; and
- Signature of person responsible for selecting.

When selecting and preparing samples for testing, prevent deformation and heating, exposure to UV light and other environmental factors, which can affect material properties.

The number of samples selected for testing shall meet the requirements in Table 7.

E.3.2 Overall length of samples as per scheme A in compliance with Б.2.3 Annex Б.

E.3.3 Samples for testing as per scheme B in compliance with Д.2.2 Annex Д.

E.3.4 The concrete mix shall be placed in compliance with Д.2.6 Annex Д.

E.3.5 Requirements to concrete in compliance with Д.2.7, Д.2.8 Annex Д.

E.3.6 The end surfaces of samples as per schemes A and B shall be coated with a thin layer of epoxy resin to prevent alkali solution infiltration into the rod body.

E.3.7 Test samples prior to testing shall be held in compliance with the requirements of GOST 12423.

E.4 Test equipment and materials

E.4.1 The test machine as per GOST 28840 shall ensure the following:

- A stress exceeding sample strength when testing for controlled parameter;
- Measuring stress and distance between traverses with an error of maximum 0.5 %;
- Speed of travel of active traverse within 5 to 100 mm/min.

E.4.2 The alkali solution shall simulate the concrete liquid phase and have the composition: 8.0 g NaOH and 22.4 g KOH per 1 litre of distilled water.

E.4.3 The alkali solution pH shall be within 12.6 to 13. Prior to and during testing, the alkali solution shall be kept in a closed vessel to prevent interaction with air CO_2 and evaporation.

E.4.4 Test couplings in compliance with Table Б.1 Annex Б.

E.5 Testing

E.5.1 Tests as per scheme A are conducted as follows:

- Prior to being dipped into the alkali solution, the sample should be dried to constant mass m_0 at (100 ± 2) °C;
- The samples are placed in an alkali solution at constant temperature (60 ± 3) °C for 30 days. In so doing, the working section between test couplings can be kept in the alkali solution rather than the whole sample;
- After being aged, the sample is taken out of the alkali solution, washed in distilled water, dried at (100 ± 2) °C for no less than 4 hours, and then weighed (m_1);

- Test couplings are placed on the rods and tested for elongation until complete failure in compliance with Annex Б.

E.5.2 Samples are tested as per scheme B as follows:

- The samples are placed in an alkali solution at constant temperature (60 ± 3) °C for 30 days. In so doing, the part of the sample that adheres to concrete can be kept in the alkali solution rather than the whole sample;
- After being aged, the sample is taken out of the alkali solution;
- The test coupling intended for fastening the sample to the test machine is placed on one end of the sample, and the second end of the sample (kept in the alkali solution) is embedded in concrete in compliance with Д.2.3, Д.2.4 Annex Д;
- After the concrete has been cured for 28 days, the sample is placed in the test machine as per the scheme shown in Fig. Д.3;
- Tests are conducted as per Д.4.2, Д.4.3, Д.4.4, Д.4.6, Д.4.8, and Д.4.10 Annex Д, and the ultimate strength of adhesion to concrete is determined.

E.5.3 The alkali solution pH as per schemes A and Б is measured prior to and after tests.

E.5.4 The external appearance of the sample (colour, changed surface and geometric dimensions) is checked prior to and after having been kept in an alkali solution in compliance with 8.1 и 8.8.

E.5.5 During tensile tests, the sample is stressed with a rate of 5 to 15 mm/min.

E.5.6 When being pulled out from cube tests, the sample is stressed with a maximum rate of 20 N/min or 1 mm/min.

E.5.7 The properties of rod materials are evaluated only when the samples have failed in the working sections. In those cases when failure or slipping occurs in the test coupling zone, data are rejected and additional tests are conducted with samples from the same batch.

E.6 Result interpretation

E.6.1 Rod mass variation Δm, %, is calculated with formula

$$\Delta m = \frac{m_1 - m_0}{m_0} 100, \qquad (E.1)$$

where m_1 is sample mass after being aged in the alkali solution, g;

m_0 is sample mass in the initial condition, g.

E.6.2 The ultimate tensile strength is calculated with formula (Б.1).

E.6.3 Variation of ultimate tensile strength, $\Delta\sigma_в$, % calculated with formula

$$\Delta\sigma = \frac{\sigma_{в1} - \sigma_в}{\sigma_в}, \qquad (E.2)$$

where$\sigma_{в1}$ is ultimate strength after ageing, MPa;

$\sigma_в$ is ultimate strength in the initial condition, MPa.

E.6.4 The ultimate strength of rod adhesion with concrete is calculated with formula (Д.3) Annex Д.

E.6.5 The variation in ultimate strength of adhesion with concrete, $\Delta\tau_r$, % is calculated with formula

$$\Delta\tau_r = \frac{\tau_{r1} - \tau_r}{\tau_r}, \qquad (E.3)$$

whereτ_{r1} is ultimate strength of adhesion after being aged, MPa;

τ_r is ultimate strength of adhesion in the initial condition, MPa.

Statistical treatment of test results is done in compliance with requirements of GOST 8.207.

E.7 Test report

The test report shall include the following:

- Information about samples given in the sample selection report;
- Name of testing organisation;
- Test date;
- Information about test conditions;
- Geometric characteristics of each sample;
- Information about test conditions (alkali solution composition, pH, temperature, and ageing time);
- Values of measured characteristics for each sample (mass variation, ultimate tensile strength, and elasticity modulus);
- Values of characteristics of each sample obtained during treatment of test results;
- Average values of characteristics and results of statistical treatment of obtained data;
- Sample 'stress-strain' diagrams;
- Information about specialists who conducted tests and their signatures.

Annex Ж
(for reference)

Method of determining the ultimate service temperature

Ж.1 General provisions

This method establishes the procedure of determining the temperature of onset of PFB softening by results of thermo-mechanical tests.

Ж.2 Method Essence

The method is based on analyzing the thermo-mechanical diagram obtained when subjecting a sample to a transverse 3-point bending test to a given deflection value, heating the bent sample in a heating chamber, and registering stress variation with temperature growth.

With growing temperature, sample resistance to bending decreases. This occurs because the composite polymer matrix resistance to shear stresses existing in a short bent sample decreases. The rate of decrease of sample resistance to bending has a maximum value at the point in time when the sample polymer matrix being heated starts to pass from a vitreous state to an elastic one, i.e. starts softening.

Subsequent differential-thermal analysis of the diagram obtained during testing, which describes the sample bending resistance vs. temperature dependence, determines the temperature, at which matrix softening has started.

Ж.3 Samples

Ж.3.1 Test samples are selected randomly from the PFB batch being checked and accompanied obligatory with a sample selection report indicating the following:

- Name of manufacturer;
- Conventional designation;
- Type of fibre and bonding substance;
- Manufacture date;
- Batch No.;
- Number and dimensions of samples;
- Indicators, for checking of which samples were selected; and;
- Signature of person responsible for selecting.

When selecting and preparing samples for testing, prevent deformation and heating, exposure to UV light and other environmental factors, which can affect material properties.

The number of samples selected for testing shall meet the requirements in Table 7.

Ж.3.2 The length of test samples shall be 12d. The length of the working section of these samples shall be within $9d \pm 2$ mm.

Ж.3.3 Before being tested, the test samples are aged in compliance with requirements of GOST 12423.

Ж.4 Test equipment and materials

Ж.4.1 The test machine as per GOST 28840 shall ensure the following:

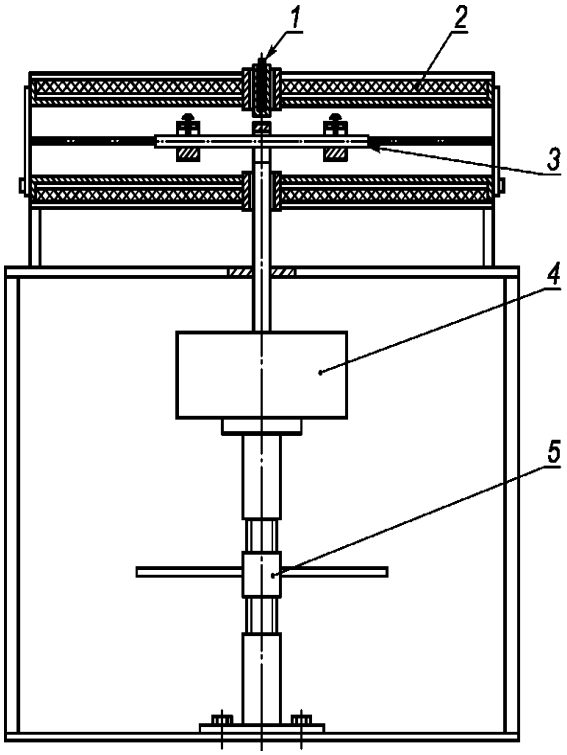
– A stress exceeding sample strength when testing for the controlled parameter;
– Measuring the stress and distance between traverses with a maximum error of 0.5 %;
– Speed of travel of active traverse within 5 to 100 m/min.

Ж.4.2 The samples shall be tested using the device shown in Fig. Ж.1.

Ж.4.3 The device comprises the following:

– A heating chamber mounted on a frame to heat samples to 200°C;
– A stressing mechanism;
– A strain transducer with a maximum measurement error of 0.5 %; and
– A temperature sensor with a maximum measurement error of 1 %.

The device shall feature means for heating speed control that ensure temperature growth in heating chamber within 1.0 + 0.2 °C/min and software measuring system for logging and processing test results.

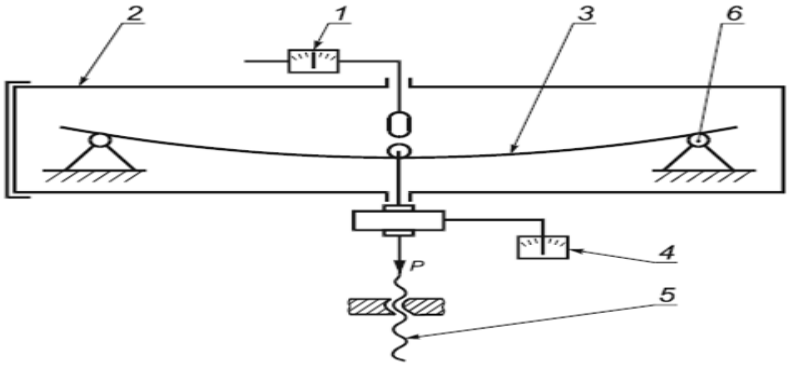


1 — temperaturealterationsensor; *2* — heating chamber; *3* — sample; *4* — strain gage; *5* — stressing grip

Figure Ж.1 — Device for thermo-mechanical test

Ж.4.4 Diagram of sample testing during determination of starting temperature of its softening (see Figure Ж.2):

- sample with 3 with supports 8 is placed to the heating chamber 2 cooled down to room temperature;
- sample is bent through pressing tip of stressing device 5 to the necessary deflection;
- record chamber temperature and respective sample resistance to bending with sensors 6 and 7 during the entire testing;



1 — temperature sensor; 2 — heating chamber; 3 — sample; 4 — strain gage; 5 — stressing device; 6 — support

Figure Ж.2 — Diagram of testing sample for starting sample softening temperature

- activate heating chamber for heating speed of approx.. 1 °C/мин and gradually heat up to the temperature above the temperature value at the second α-junction point;
- during heating process record temperature inside the chamber and respective sample resistance to cross bend at respective intervals of time.

Ж.5 Sample testing

Ж.5.1 Testing conditions shall be as per Section 3.15 of ГОСТ 15150.

Ж.5.2 Stress applied to the sample shall be 10 % of collapse stress for specified test base (distance between supports). Estimated collapse stress value P, N, is calculated using formula below

$$P \approx \frac{4\sigma_в w}{l_р} \qquad (Ж.1)$$

wherelp is length of specific area of sample, mm.

For circular section samples w, mm3, is calculated using formula

$$w = \frac{\pi d^3}{32} \qquad (Ж.2)$$

Ж.5.3 Testing device is set up for value of test base corresponding to the valie of lp.

Ж.5.4 Set up temperature sensors and strain gage.

Ж.5.5 Put sample to the device so that the tip of the device applies stress to the middle of test section of the sample between supports.

Ж.5.6 Using stressing device bend the sample until stress applied to it is equal to the stress as per Ж.5.2. Stress is monitored by the readings of strain gage.

Ж.5.7 Hold the sample at such state for at least 5 minutes. Then switch on heating chamber and monitor temperature change within it.

Ж.5.8 After temperature increase by 1 °C start recording of thermo-mechanical graph — array of temperature and strain values (Tj, Pj).

Ж.5.9 Record the array at temperature change increment of not more than 2 °C.

Ж.5.10 Upon completion of test sample is removed from the chamber, and chamber is cooled down to room temperature.

Ж.6 Result interpretation

Ж.6.1 Analyze thermo-mechanical graphs for each tested sample during result interpretation.

Ж.6.2 Plot a thermo-mechanical graph with coordinates P(T), using array (Tj, Pj), and special data processing software such as «Microsoft Excel».

Ж.6.3 Visually evaluate approximated point of borders of starting and main section of diagram on the graph. If necessary, location of borders of starting and main section of diagram can be clarified during repeated data processing.

Ж.6.4 Starting section of thermo-mechanical curve (preceding the beginning of polymer matrix softening) is approximated by linear function of Pj = mTj + n and using data processing software constants m and n for this function are calculated.

Ж.6.5 Calculate reduced stress P1j for each array value using formula below

$$P_{1i} = \frac{P_i}{(mT_i + n)} \qquad (Ж.3)$$

where Tj is temperature value for array, °C;

Pj is strain value for array, N;

m and n are values of empirical constants of the line, approximating starting section of ratio between stress Pj, at which sample resists the bend and temperature Tj in heating chamber.

Ж.6.6 Plot new data array (Tj,Pji), and approximate its main section with sigmoid function using formula below

$$P_1 = a + \frac{b}{\left(1+\exp\left(-\frac{T-c}{d}\right)\right)}, \quad (Ж.4)$$

where a, b, c, d are empirical constants of sigmoid function approximating test data.

To calculate constants use function No. 8011 from software «Table Curve Windows v. 1.10».

Ж.6.7 Using «Table Curve Windows v. 1.10» application find the values for the first and second derivative temperature of math function [P1 (T)] and approximate test section of ratio between reduced stress values P1j, applied to the sample during test and temperature values T in heating chamber.

Ж.6.8 Temperature at which the second derivative of the [P1 (T)] function has minimum value is considered temperature Ta, for which numeric values of function P1 (T) and its first derivative дP1/д7 are found on thermo-mechanical diagrams.

Ж.6.9 Temperature at which the second derivative of function [P1 (T)] has maximum value is deemed to be temperature T1a.

Ж.6.10 Temperature at which the first derivative of function [P1 (T)] has minimum value is deemed to be temperature TC,°C.

Ж.6.11 Obtained values Ta, T1a and TC are used to evaluate correctness of initial evaluation of border of starting and main section of thermo-mechanical curve graph and decision is made as to whether or not additional analysis of the curve graph is needed.

Ж.6.12 Ultimate service temperature Тэ, °C, is calculated using formula

$$T_э = T_{1a} - \begin{pmatrix} (1-P_{1a})\cos(0) \\ (1-\sin(0)) \end{pmatrix}, \quad (Ж.5)$$

$$\theta = \frac{\pi}{2} + \operatorname{arctg}(\partial P_1/\partial T). \quad (Ж.6)$$

Ж.7 Test precision

Ж.7.1 Tolerance of temperature measurement in heating chamber shall not exceed 2 °C.

Ж.7.2 Tolerance of measurement of sample resistance to cross bending shall not exceed 0.5 % of maximum value of strain obtained during the test.

Ж.7.3 Determination tolerance of parameters tested, constants and other values used in intermediate calculations shall not exceed 0.001.

Ж.8 Test report

Test report shall include the following:

- Information about samples, set forth in sampling report;
- Date of testing;
- Data on conditions of test;
- Test results;
- Values for tested parameters for each sample;

- Values of tested parameters for sample, obtained during result interpretation;
- Mean values of tested parameters and results of statistical analysis of data;

- Initial thermo-mechanical diagram for each sample;
- Reduced thermo-mechanical diagram for each sample;
- Diagram of ratio between the first derivative of reduced stress and temperature for each sample;
- Diagram of ratio between the second derivative of reduced stress and temperature for each sample;
- Information about staff performing tests and their signatures.

Annex И
(for reference)

Data Sheet Form

DATA SHEET No.

Manufacturer:
(name, address, phone, fax) _____

Date of manufacture _____

Shipment date _____

FPB legend _____

Batch No._____ _____

Batch weight, kg _____
Total length of batch _____m _____
Number of items per package _____pcs. _____

Regulated quality properties

Certificate (if certified)

Other regulated quality properties (if necessary)

Issuance date _____ ___, 20__

Head of laboratory _____ / _____ /
(signature)

QCD _____ / _____ /
(signature)

Packing operator _____
(signature)

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