INTERSTATE COUNCIL FOR STANDARDIZATION, METROLOGY AND CERTIFICATION
(ISC)
ULUSLARARASI STANDART

GOST 31938 - 2012

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COMPOSITE POLYMER REINFORCEMENT (ARMATURE, FRAMEWORK) FOR THE REINFORCEMENT OF CONCERETE STRUCTURES (CONSTRUCTIONS)

General Technical Specifications
(ISO 10406-1: 2008, NEQ)

Official Publication
(sealed)

Moscow
Standard inform
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Introduction

Goals, main principles and main procedures of interstate standardization affairs, GOST 1.2-92 "Interstate Standardization System", General Provisions" and GOST 1.2-2009 "Interstate Standardization System". Interstate standards, rules and recommendations on interstate standardizations. Development, acceptance, implementation, renovation, and rules on cancelation".

Information of standard

1. It's been prepared and improved by the collaboration of "NİİJB" A.A. Gvozdev Scientific Research, design and Concrete, Reinforced Concrete Technology Institute, and OAO "NİTS" "Construction" Open Joint Stock Company, OOO "Biyski Fiberglass Factory" and the involvement of OOO "TBM" Ltd. Co.

2. It's been SUBMITTED by TK465 "Construction" Standardization Technical Council.
3. It's been accepted by Scientific and Technical Commission of Interstate Standardization, Technical Norms and Conformity Assessment. (Report #41 on 18 December 2012.)

Here are the authorities casting affirmative vote for acceptance:

Short name of country as per MK (ISO 3166), 004-97 rules	Country Code MK (ISO 3166), 004-97	Short Name of State Construction Organ (Institution)
Azerbaijan	AZ	Ministry of Construction
Armenia	AM	Ministry of Urban Development
Belorussia	BY	Ministry of Construction and Architecture
Kyrgyzstan	KG	Ministry of Construction
Moldova	MD	Ministry of Construction
Russia	RU	Ministry of Regional Development
Tajikistan	TJ	State Institution of Construction and Architecture
Uzbekistan	YZ	Gosarkhitektstroy

4. Related standard, ISO 10406-1:2008 Reinforcement of Concrete with fiber reinforced polymer (FRP) – Test Methods - Part 1: FRP bars and grids (Reinforcement of concrete with plastic and reinforced fiber (FRP), Test Methods. Part 1. Bars and grids made of FRP.
Goodness of Fit: not equivalent (NEQ)

5. On 1 January 2014, Interstate Standard GOST 31938 was put into force as national standard of Russian Federation, in accordance with the ordinance # 2004-st dated 27 December 2012 by State Institution of Technical Arrangement and Metrology.

6. FIRST ENFORCEMENT

The information of the changes in this standard is announced in annual info guide “National Standards” (as per the status of current year as of January 01), the letters or text of changes and amendments are announced in monthly guide “National Standards”. In case of re-assessment (amendment) or termination of this standard, related declaration will be published in monthly info guide “National Standards”. Related information, declarations and texts (letters) are also put into the system in relation to general use, that is to say, they are published on official website of Federal Institution of Technical Regulation and Metrology.

GOST 31938-2012

INTERSTATE STANDARD

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COMPOSITE POLYMER REINFORCEMENT (ARMATURE, FRAMEWORK) FOR REINFORCEMENT OF CONCRETE STRUCTURES (CONSTRUCTIONS)

General Specifications

Fiber-reinforced polymer bar for concrete reinforcement. General specifications

Enforcement Date - 01/01/2014

1. Application Field

This standard determines general specifications and includes periodic profile composite polymer reinforcements (armatures) (AKP) that are intended for reinforcement of conventional and pre-stressed construction structures and elements under aggressive environments and that are compliance with GOST 30247 standard "fire-resistance" and GOST 30403 "safety for fire".

This standard does not include flat profile polymer bars and composite polymer flexible joints.

2. Normative References (references)

This standard refers to following standards:

GOST 8,207-76 State system of integration in measurements. Direct measurements with multiple observation. Analysis methods of observation results.
GOST 12.1.044-89 System of occupational safety standards. Fire and explosion risk of substances and materials. Denomination and determination of indexes.
GOST 17.2.3.02-78 Environmental Protection. Atmosphere. Rules and determination of allowable emissions from hazardous materials in industrial enterprises.
GOST 166-89 (ISO 3599-76) Beam measurement compass - metal measurements. Technical Specifications.
GOST 427-75 Metal Rulers for measurement. Technical Specifications.
GOST 3560-73 Steel Strip for Packaging. Technical Specifications.
GOST. 4651-82 Plastics. Compression Test Method.
GOST 6507-90 Micrometers. Technical Specifications.
GOST 7502-98 Metallic Measurement Rulers. Technical Specifications.

GOST 10884-94 Thermo-Hard Reinforcement Iron (Steel) for Reinforced Concrete Structures. Technical Specifications.
GOST 12004-81 Concrete Steel. Tensile test methods.
GOST 12423-66 Plastics. Conditions of acclimation and testing of samples.
GOST 14192-96 Marking Goods (loads)
GOST 14359-69 Plastics. Mechanical test methods. General Requirements.
GOST 15139-69 Plastics. Density determination methods (mass density)
GOST 15150-69 Machines, equipment and other technical products. Performance for different climate zones. Categories, usage - operation, storing and transportation conditions - section: impacts of outer environment climate factors.
GOST 16504-81 Official testing system for products. Product testing and quality control. Basic concepts and definitions.
GOST 17308-88 Twines. Technical Specifications.
GOST 28840 – 90: Tensile, compression and bending test machines for materials. General specifications and requirements.
GOST 30108-94 Construction materials and manufactures. Determination of natural radionuclide special-efficient AC productivity.
GOST 30.247.0-94 Constructional structures. Test methods for fire safety. General specifications and requirements.
GOST 30403-96. Construction structures. Test methods for fire resistance. General specifications and requirements.

Note – In use of this standards, it recommended that data system reference standards for common use is controlled through website of Federal Institution of Technical Regulation and Metrology, or "National Standards" annual info guide as of January 01 in each year and "National Standards" monthly info guide. In case of any amendment in reference standard without replacement with new standard, only related section in related standard is amended.

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Official Edition

3. Terms and definitions

In this standard, the terms in accordance with standards GOST 10884 and GOST 12004 and the following terms are used:

3.1. Component (Composite): The solid material that consists of one or more materials and is different from each other in terms of shape and/or phase and/or chemical compound and/or characteristics, and that are principally linked with physical connections, and that has separation limit among compulsory material (matrix) and its fillers-filler materials as well as booster fillers.

Note – Matrix and filler material of composite forms a single structure and shows an activity together, thus it provides the best necessary specifications for the functional aim of final product.

3.2. The matrix of polymer composite is a structure consisting of hardened thermo-active resin that provides the integrity of polymer compound, transfer and distribution of stress, heat-resistance, damp-proofing and fire-resistance as well as chemical-resistance of polymer composite,

3.3. **Thermo-active resin:** the thawless and insoluble resin that has three-dimensional caged structure under temperature and/or chemical reaction and/or chemical reactions. A solid material can be injected thanks to three-dimensional web structure …..
Note – Unsaturated polyesters, epoxy, vinyl ester, phenolic resins, organic and other type organic resins are included in thermo-active resin.

3.4. Thermo-active resin filler, filling material: the material that is combined with thermo-active resin up to beginning of hardening - solidification process in order to give necessary characteristics to resin and/or matrix or reduce the value of final product.

3.5. Booster filler material: the material or product that is combined with thermo-active resin before solidification process in order to improve physical and mechanical characteristics of polymer composite.

Notes:

1. In this standard, the terms "Supportive (booster) filler material" means booster filling material that is made of continuous fiber. This term has not the same meaning as "filling material".
2. Fiberglass, basalt fiber, carbon fiber and aramid fiber supportive filler materials are used for production of AKP.

3.6. Fiber: The material that is used for production of fibrous materials for hardening polymer composites, and that has small transverse sizes in lengths and flexible, continuous and strong structure with limited lengths.

Notes:
1. Thickness and diameter of fiber is included in transverse sizes.
2. Depending on production technology, that is continuous or staple fiber.

3.7. Fiberglass: fiber glass (fiber): the fiber that consists of inorganic glass metal and is used for hardening polymer composite.

3.8. Basalt fiber; basalt fiber (fiber): the fiber that consists of basalt or gabbro-diabase and is used for hardening polymer composite.

3.9. Carbon fiber (fiber carbon); carbon fiber (fiber): the fiber that consists of pyrolysis of organic fibers of precursors and is used for hardening polymer composites; it compromises at least 90% of carbon mass.

Notes
1. Precursors, for example, includes poly acrylic nitrile or hydrate cellulose fibers.

2. Depending on tensile limit and elasticity modulus, carbon fibers are divided into general purpose, high resistant, medium modulus, high modulus and ultra high modulus fibers.

3.10. Aramid fiber: The aramid fiber that consists of polyamide, a linear fiber creator, and is used for hardening plastic composites; at least 85% of amid group dir0ectly links to two aromatic rings.

3.11. Glass composite: a polymer composite that compromises continuous supportive filler material from fiber glass.

3.12. Basalt composite: a polymer composite that compromises continuous supportive filler material from basalt fiber.

3.13. Carbon composite: a polymer composite that compromises continuous supportive filler material from carbon fiber.

3.14. Aramid composite: a polymer composite that compromises continuous supportive filler material from aramid fiber.

3.15. Combined composite: glass composite or basalt composite or carbon composite or aramid composite that compromises an additional different fiber type or continuous supportive filler material.

3.16. Periodic profile composite-reinforcement material (armature); polymer composite reinforcement material (armature); a reinforcement bar that is made of thermal reaction resin, continuous supportive material and other filler materials; binder layers are homogenously and longitudinally placed on the surface.

3.17. Outer diameter of composite polymer reinforcement material (armature); outer diameter: the diameter that allows to determine nominal diameter by direct measurement over periodic offsets on reinforced bar.

3.18. Nominal diameter of composite polymer reinforcement material (armature); nominal diameter: the diameter of circular plain bar with the same volumetric sizes, which is determined for marking of reinforcement material (armature) and is used to calculate physical and mechanical characteristics as well as the construction.

3.20. Strength Limit of adhesion to Concrete: the sheer stress occurring in the limit of adhesion to concrete during removing reinforcement material (armature) from concrete.

3.21. Strength limit in crosscut: the sheer stress occurring in reinforcement material (armature) under cutting power.

3.22. Operation limit temperature: the temperature reducing in physical and mechanical characteristics of reinforcement material (armature) due to softening of polymer composite matrix.

3.23. Reinforcement bar: continuous carrying bars that determine the physical and mechanical characteristics of reinforcement material (armature).

3.24. Anchorage layer: the transverse offsets that are formed with the adhesion of continuous fibers to reinforcement bar and that are intended for increasing the adhesion of reinforcement material (armature) to concrete.

3.25. Periodic profile step: the distance between two traverse offsets, which is measured in parallel with plane axis of power bar.

4. Categorization, main parameters and measures

4.1. Depending on type of continuous reinforcement filling, reinforcement polymer composites are categorized as:

ASK - glass composite;
ABK - basalt composite;
EUK - carbon composite:
AAK - aramid composite;
AKK – combined composite.

4.2. Polymer composites are manufactured with following nominal diameters in Table 1:

Table 1

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

Note - Provided that they comply with the requirements of this standard, polymer composites may be manufactured in different diameters.

4.3. Outer diameter of polymer composites must not be less than the diameters mentioned in manufacture documentation.

4.4. Depending on aggressive environments, polymer composites may have different periodic profile that allows the strong adhesion of bars to concrete.

4.5. Depending on manufacture documentation in relation to polymer composites, following geometrical sizes as well as deviation limits of period profile must be specified:

- Nominal diameter;
- Outer diameter;
- Step of periodic profile;
- Nominal field of cross section.

4.6. Composite polymers are manufactured in bars having lengths of 0,5 – 12,0 m with 0,5m. of steps, and the bars with more lengths may be possible.

4.7. Deviation limits must be in compliance with following values specified in Table 2.

Table 2

Length of bar, m	Maximum deviations in length, mm
Including 6, up to 6	+25
From 6 to 12	+35
12	+50

4.8. It is possible to provide polymer composite reinforcements in wrappings or rolls with 4-8 mm of nominal diameter.

4.9. Minimum diameter of wrapping or roll d_b must protect the polymer composite reinforcements from transportation and storing conditions to its use, this diameter is calculated by following formula:

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

Here, d - nominal diameter, mm;

$\sigma_в$ - tensile strength limit, Mpa;

E_f - elasticity modulus in tensile, Mpa.

4.10. Marking of polymer composite reinforcements must include following respects: Type of product must be marked as per fiber type in accordance with 4.1; nominal diameter maximum strength in tensile; elasticity modulus in tensile; and marking of this standard.

Examples of marking:
- 12 mm glass composite reinforcement material (armature) with max. tensile strength - 1000 Mpa, elasticity modulus in tensile 50 GPa.

ASK 12-1000 / 50 - GOST 00000-2012

- 10 mm Combined composite filling material (armature) with continuous fiberglass and basalt fiber filling materials, max. tensile strength 1300 Mpa, elasticity modulus in tensile 90 Gpa (main filling material is fiber glass material, basalt fiber filling material is secondary (auxiliary) material):

AKK (SB) -10-1300-1390-GOST 00000-2012

5. Technical Requirements

5.1. Basic indicators and characteristics

5.1.1. Composite polymer reinforcements must be manufactures as per current laws and procedures as well as technical documentation, and they must be in compliance with the requirements of this standard.

5.1.2. Composite polymer reinforcements must be made of thermal reaction resin and it must compromise at least 75% of continuous reinforcing filling material as per the mass.

5.1.3. Depending on physical and mechanical indicators, composite polymer reinforcements must be in compliance with the requirements specified in Table 3.

Table 3

Indicator	Norm
Tensile Strength σ_g, Mpa, minimum	As per requirements in Table 4
Elasticity modulus in tensile, Gpa, minimum	As per requirements in Table 4
Maximum strength in compression, σ_s Mpa, minimum	As per requirements in Table 4
Max. strength in crosscut, $\tau_{дп}$, МПа, minimum	As per requirements in Table 4
Adhesion to concrete, max. strength $\tau_п$, МПа, minimum	12
Reduction in max. strength under alkali environment pursuant to adhesion, $\Delta\sigma_{вг}$, %, maximum	25
Limit of adhesion to concrete under alkali environment, $\tau_п$, МПа Mpa, minimum	10
Operating temperature $T_э$, °С, minimum	60

5.1.4. Different physical and mechanical characteristics of composite polymer reinforcements must meet the requirements specified in Table 4:

Table

Indicator	ASK	ABK	AUK	AAK	AKK
Max. tensile strength (strength limit) $\sigma_{вг}$, Mpa, minimum	800	800	1400	1400	1000
Elasticity modulus in tensile $E_{р}$, Gpa, minimum	50	50	130	70	100
Strength limit in compression $\sigma_{вс}$, Mpa , minimum	300	300	300	300	300
Strength limit in crosscut, $\tau_{сдв}$, Mpa, minimum	150	150	350	190	190

5.1.5. Tensile strength limit and elasticity modulus of composite polymer reinforcement must not be less than the values specified in manufacture documentation. In case that the values in relation to strength limit and elasticity modulus are higher in manufacture documentation, the requirements in manufacture documentation must be met, and the instructions of manufacture must be followed.

5.1.6. Design and manufacture of composite polymer reinforcement under climate conditions – UXL2 in accordance with GOST 15150 standard.

5.2. **Requirements in relation to appearance.**

5.2.1. Definition indicators in relation to trademark categorization of composite polymer reinforcement, geometrical indicators and periodic profile parameters must be specified in manufacture documentation.

5.2.2. Depending on appearance (defects, deficiencies), composite polymer reinforcements must be in compliance with requirements specified in Table 5:

Table 5

Definition of Deficiencies	Norm of limitation
Cracks	Not allowed
Stratification	Not allowed
Crust	Not allowed
Compressions due to damage of wrappings	Not allowed
Crashed areas with damaged fibers due to mechanical impact	Not allowed

5.3. Requirements in relation to raw material

5.3.1. The materials used for manufacture of composite polymer reinforcements must be in compliance with normative documentation (regulations) and technical documentation, and also these materials are certified with the certifications and

their appendices, test reports proving that those are in compliance with normative documentation and technical documentation.

5.4. Marking

5.4.1. The markings on packaging of products must be clear and easy-readable.

5.4.2. Markings must be performed with labels.

5.4.3. Markings are carried out by printing them on labels.

5.4.4. Each boxes must carry related labels. The labeling method and label place on the box are specified in manufacture documentation.

5.4.5. Label place must specify a visual definition of product without damaging packaging.

5.4.6. Marking must not be damaged during storing, transportation, loading and unloading operations and life cycle of product.

5.4.7. Composite polymer reinforcement marking must include following information:

- Definition (name);
- Country of Manufacture;
- Manufacture company - enterprise;
- Legal address of manufacture;
- Trademark (brand of product), manufacture company;
- Basic consumption characteristics and / or qualifications;
- Certification Info;
- Batch number and date of manufacture;
- Composition/Composite/(Precision);
- Mandatory marks (symbols);
- Number of products in a packing unit;
- Total length of packing unit;
- Seal of Quality Controller and Signature of Person preparing the packaging;
- Standards and/or technical specifications in relation to manufacture and definition of product;
- Barcode;
- Transportation marks as per GOST 14192 standard, as well as "Protect From Moisture";

Note – When marking composite polymer reinforcements, the related norms about marking procedures in the governments of parties in an Agreement must be followed.

5.5. Packing

5.5.1. Packing must protect the integrity of composite polymer reinforcement during loading and unloading operations.

5.5.2. A batch of composite polymer reinforcement material in a scale length must be packaged in bundles, and it is possible to package in wrappings or rolls as per paragraph 4.8 upon reaching a mutual understanding with the consumer.

5.5.3. Dense, jammed stacking of composite polymer reinforcement materials in a scale of length is suitable; they must be strictly bounded transversely with 1-1,5 m of intervals, also the distance from bond edges to the farthest areas must be 10-20 cm.

5.5.4. Wrappings must be bonded with double full bonds (diametrically opposite), the bundles of wrappings must be properly bonded with double or triple bonds.

5.5.5. For bonding, twines in accordance with GOST 17308 standard or tapes in accordance with GOST 3560 standard are used.

5.5.6. During manual loading and unloading operations, the weight of wrappings, rolls or other type of composite polymers must not exceed 80 kg.

5.5.7. During machine loading or unloading, the weight of wrappings, rolls or other types are determined in accordance with types and specifications of lifters in manufacture company and consumers. Manual loading is discussed when placing an order.

6. Requirements in relation to environmental safety and protection

6.1.1. Under normal operation conditions, hazardous and toxic substances for human and environmental health must not be released in accordance with Part 9 when composite polymer reinforcements are transported and stored.

6.1.2. Regarding to hygiene requirements (1), composite polymer reinforcements must be in compliance with Table 6.

6.1.3. Manufacture of composite polymer reinforcements must be carried out in compliance with conditions as per (2) and (3).

6.1.4. Manufacture must be in compliance with final product manufacture controls as per (4) and (5) in relation to control of hazardous manufacture factors and hygiene factors that have been approved in manufacture company.

6.1.5. In implementation of composite polymer reinforcements, requirements of Environmental Protection specified in GOST 172302 must be observed.

Table 6

Indicator	Index (indicator) value
Odor level, maximum	Level 2
As per (6), concentration of volatile substances, maximum: - Phenol - Formaldehyde - Toluol	 0003 mg / m^3 0003 mg / m^3 0600 mg / m^3
As per (7), specific activity of natural radionuclide $A_{eff.}$, maximum	370 Bk / kg

6.6. Recycling and treatment of composite polymer reinforcements wastes must be carried out in accordance with current legislation in relation to environmental protection. Requirements in relation to environmental safety and protection are specified in manufacture company documentation.

6.7. Fire and explosion risk indicators are specified in documentation of composite polymer reinforcement manufacturer according to GOST 12.1.044 standard, and transportation and protection conditions are determined as per these provisions.

7. Rules on acceptance

7.1. Composite polymer reinforcement are accepted in the batches according to requirements of this standard. A batch must include composite polymer reinforcements that have the same combination and type, single brand materials, same normative documentation and technology and that have been manufactured in at least 3 hours including breaks and stops. The volume of a batch is specified in normative documentation of manufacture company.

7.2. Each batch must have a passport (see Annex "I").

7.3. Regarding to quality, composite polymer reinforcement is accepted by technical control service in manufacture company, and following manufacture control types must be foreseen in accordance with GOST 16504 Standard;

- Access Control - quality of raw materials used in manufacture of composite polymer reinforcement, their compliance with normative documentation, technological regulations are inspected.
- Operational control - the compliance of hardware and technological parameters of composite polymer reinforcement with technological regulations;
- Acceptance control - level and indicators of composite polymer reinforcement quality in accordance with requirements of this standard;

7.4. In order to control composite polymer reinforcement in accordance with requirements of this standard, following tests must be carried out according to GOST 16504 standard:

- Acceptance-delivery tests;
- Periodic tests;
- Type tests.

7.5. Acceptance and delivery tests are carried out for each batch.

7.6. Pursuant to final periodic tests, periodic tests are carried out 6 months later (in the first year of manufacture) and carried out 1 year later as of final periodic test (for following years of manufacture).

In order to carry out periodic tests, one composite polymer reinforcement batches, which is suitable for manufacture control and acceptance-delivery test results as well as this standard is selected.

7.7. Results of periodic tests include all composite polymer reinforcement batches that are manufactured between two consecutive ordinary periodic testing periods.

7.8. Results of acceptance-delivery and periodic tests must be specified in passport of product in order to determine the indicators of composite polymer reinforcement.

7.9. Type tests are carried out in following cases:
- Changes in raw materials;
- Any amendment or change in normative documentation in relation to any raw material;
- Upon request of consumer and any certification process.

7.10. Number of controls in each test type is specified in Table 7.

7.11. Competence tests are carried out for at least the first 3 batches as per all indicators specified in Table 7 in case of new manufactures of composite polymer reinforcement or in case of manufacture by using new hardware.

7.12. Depending on indicators, if negative results is obtained at the end of tests, the tests on double samples will be carried out again. If negative results persist, related batch is discarded; manufacture of composite polymer reinforcement is stopped; the reasons causing negative results are examined and a plan is organized in order to remove negative results; a new test batch is prepared, so acceptance-delivery and periodic tests with full operation are carried out in point of indicators under negative results. If this test batch gives positive results, manufacture of composite polymer reinforcement is restarted. If this test batch also gives negative results, reasons of negative results are examined until the positive test results are obtained in accordance with requirements of this standard.

7.13. Manufacturer of composite polymer reinforcement must guarantee at least 95% compliance with requirements specified in paragraphs 5.1.3-5.14., and the compliance with the requirements for each year with respect to statistical analysis of acceptance-delivery and periodic tests during the manufacture period.

Table 7

Control Indicators	Test Type			Volume of samples from batch
	Acceptance-Delivery Tests	Periodic Tests	Type Tests	
Appearance	+	-	+	Minimum 10 %
Geometrical sizes: - outer diameter, d_{outer} - nominal diameter, d - length, l	+ + +	- - -	+ + +	At least 3 items in acceptance-delivery tests; at least 6 items in
Tensile strength limit, $\sigma_в$	+	-	+	

				periodic and type tests.

End of Table 7

Control Indicator	Test type			Volume of samples from batch
	Acceptance-Delivery tests	Periodic tests	Type Tests	
Elasticity modulus in tensile, E_f	+	-	+	At least 3 items in acceptance-delivery tests; 6 items in periodic and type tests.
Pressure strength in compression, σ_{ac}	-	+	+	
Tensile strength in cross section, τ_{sh}	-	+	+	
Strength limit in adhesion to concrete (tensile strength), τ_f	-	+	+	
Reduction of tensile strength under alkali environment, $\Delta\sigma_a$	-	+	+	
Strength of adhesion to concrete under alkali environment, τ_f	-	+	+	
Minimum/Maximum operating temperature, T_b	-	+	+	

7.14. In the assessment of manufacture stability, the compliance of composite polymer reinforcements is determined according to results that are obtained during a period less than 6 months. In the assessment of manufacture stability, compliance criteria of composite polymer reinforcement is given in Table 8.

7.15. The compliance of composite polymer reinforcement is determined by calculating the number of negative results of desired values and comparing this number to number of acceptances.

7.16. The actual compliance of composite polymer reinforcement is accepted, if number of negative results do not exceed the number of allowable criteria.

Table 8

Number of Tests	Number of acceptance
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. Methods of control

7.

8.

8.1. The appearance and surface quality of composite polymer reinforcement and the compliance of composite polymer reinforcement with requirements or etalon sample is visually controlled without using magnifying devices.

8.2. Outer diameter, height of composite polymer reinforcement, step of periodic profile are controlled by measurement compass in accordance with GOST 166 standard and by micrometer in accordance with GOST 6507.

8.3. The length of composite polymer reinforcement is measured with a ruler according to GOST 427 standard and with a third-class tape measure with a nominal length of 10, 20 m according to GOST 7502.

8.4. Nominal diameter is determined according to GOST 15139 standard and additional operations (see Annex A).

8.5. Mechanical characteristics in axial tension is determined according to GOST 12004 standard and changes as well as addition operations (see Annex B).

8.6. Maximum compression strength is determined according to GOST 4651 standard, changes and additional operations (see Annex B).

8.7. Maximum strength in cross section is determined according to Annex G.

8.8. Tensile strength in adhesion to concrete is determined according to Annex D.

8.9. Resistance of concrete under alkali environment is determined according to Annex E.

8.10. Operating temperature limits are determined according to Annex F.

8.11. Natural radionuclide specific activity of raw materials used in manufacture of composite polymer reinforcement is determined according to GOST 30108 standard.

9. Transportation and storage

9.

9.1. Provided that protection conditions are considered, composite polymer reinforcement are transported horizontally with all kinds of transportation vehicle according to transportation rules for loads.

9.2. Composite polymer reinforcement must be stored on horizontal racks of non-heated or heated storages; they must be away from heating devices with a distance of at least 1 m and also they must be stored at a height of at least 100 mm from the ground.

9.3. In protection, transportation and loading operations, composite polymer reinforcement must be protected from mechanical damages, ultraviolet lights and moisture.

10 Guarantees to be given by manufacture

10.

10.1. Manufacture company guarantees the compliance of composite polymer reinforcement with this standard, provided that consumer considers protection, transportation and implementation conditions.

10.2. Guarantee period for composite polymer reinforcement is 24 months as of manufacture date.

10.3. After expiration of guarantee period, composite polymer reinforcement may only be used after they are tested for full compliance with the requirements of this standard.

ANNEX A (information - as a reference) Determination method of nominal diameter

A.1. General provisions

This method depends on determination of a sample volume, which is cut from controlled product in a certain length, and the calculation of nominal diameter afterwards.

A.2. Samples

A.2.1. Test samples are randomly selected from a batch of composite polymer reinforcements controlled, and this selection is recorded in a report and this report specifies following respects:
- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- batch number;
- Number and size of samples;
- Selection indicators of samples for performance of control;
- Name of responsible for selection of sample.

A.2.2. In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.

A.2.3. Number of samples for tests must be in compliance with requirements in Table 7.

A.2.4. For the tests, the pieces of samples with a length of 1 mm, which are calculated according to following formula and cut and measured, are used:

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

and here, l_{np} is step length of periodic profile, mm.

A.2.5. Before testing samples, they are protected according to GOST 12423 standard.

A.3. Devices (apparatus) and materials

Following devices and materials are used for performance of tests:
- analytic scale with at least 2nd accuracy class;
- in addition to analytic scale, container and equipment (clamp) for hydrostatic scaling;

- Compass with maximum 01 mm units according to GOST 166 standard

A.4. Performance of tests

A.4.1. Test conditions must be in compliance with sub-parts of 3.15 GOST 15150 standard.

A.4.2. The length of both samples are measured three times provided that each measurement completes 120° degree.
Averaged value of three measurements are rounded up to 0,1 mm. For example, the length must be measured with maximum 0,1 mm of error margin.

A.4.3. The special water that is kept in room temperature for 2 hours is put into hydrostatic measurement container.

A.4.4. Before placing the sample, holding - grasping tool is submerged in the container with water, tool is set to zero or the value shown by scale is recorded.

A.4.5. The sample is placed in holding - grasping tool and the values shown by scales are fixed, and then sample is submerged by using holding - grasping tool and the value shown by scale is recorded.

A.5. Processing test results

Nominal diameter d is calculated by using following formula:

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

here, m_1 – mass of sample in the air, mg;
m_2 – mass of sample in the water, mg;
p - water density, / mm^3 (p = considered as 1);
l – sample length, mm.

Characteristic and item examined, the values used in interim calculation must be determined with maximum 0,01 (1%) of relative error margin.
Statistically processing of test results is carried out according to requirements of GOST 8.207.

A.6. Test report

A.6. Test report will include followings:
- Information about samples specified in sample selection report;
- Testing organization;
- Test date;
- Information of test conditions;
- Values of measured characteristics for each sample;
- Values of each sample characteristic that are obtained in processing of test results;
- Averaged values of standard deviations of characteristics, results of statistical processing of information and data obtained;
- Information of testing experts and their signatures.

ANNEX "B" (information – for reference) Test method of axial elongation

Tension-based test method

B.1. General Provisions

This method determines the requirements in relation to axial tension test of composite polymer reinforcement in order to specify following mechanical characteristics:

- Strength (failure) limit;
- Elasticity modulus;
- Relative elongation.

This method determines following requirements in relation to axial tension of composite polymer reinforcement:

- Failure test of sample must be carried out for allowable operation section;
- The part of sample among test sleeves, where test machine holds the samples. is considered as an operation section;
- Tangent and radial elongation impacts of test sleeves on sample failure, which occur in transition zone in the direction of the bar, is not considered.

B.2. Samples

- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- Batch number;
- Number and size of samples;
- Selection indicators of samples for control;
- Responsible for selection of samples;

In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.

Number of samples selected for tests must be in compliance with requirements in Table 7.

B.2.2. The length of test sleeves must be determined in the manner that they proceed their action in the limits of operating section without any shear.

B.2.3. Length of test sample is determined according to length of operation section and the length of two test sleeves.

Recommended structure and sizes of test sleeves for performance of tests is shown in Figure B.1 and Table B.1.
Length of operating section must be accepted as at least 40d of the bar.

B.2.4. Provided that the failure occurs in limits of operating section without any shear of test sleeves, shorter samples may be used.

B.2.5. Test samples are stored according to requirements in GOST 12423 before testing.

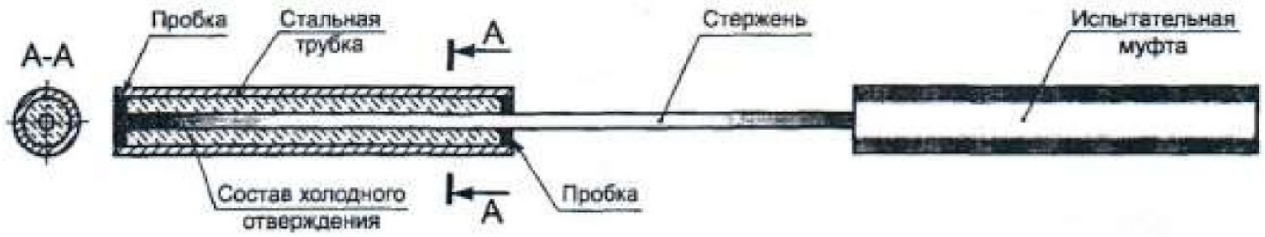


Рисунок Б.1 — Вид типового опытного образца

Figure B.1. – View of type test sample
Пробка = stopper; Стальная трубка = steel pipe; Стержень = Bar; Испытательная муфта = Test sleeve,
Состав холодного отверждения = Content of cold solidification; Пробка = stopper

Table B1 – Length of test samples and test sleeves, mm

Nominal diameter of composite polymer reinforcements	Test sleeve		
	Outer diameter	Minimum length	Wall thickness
Between 4 and 10	35	300	Between 3 and 5
»12 » 16	42	350	
» 18 » 22	48	450	
» 22 »30	60	500	

B.3. Equipment (apparatus) and materials

B.3.1. Test machine must provide following respects according to GOST 28840 standard:

- For performance of test in relation to control indicators, the loadings exceeding the sample strength;
- Measurement of the distance between the load and cross sections (transverse lines) with maximum 0,50% of error margin.
- 5-100 mm/minute active traverse shear.

B.3.2. Data record system must provide uninterrupted record of load, deformation and shear. Minimal value must be:

- 100 H …… for load (loading);
- 0,01 mm …… for deformation;
- 0,001 mm ……. for shear.

B.3.3. As the measurement of elasticity, extensometers or linear sensors are used to sensitively measure sample elongation, the length between sensors with at least 0,0002 accuracy.

B.4. Performance of tests

B.4.1. Test conditions must be in compliance with sub-parts in 3.15 GOST 15150 standard.

B.4.2. When placing sample on test machine, longitudinal axis of sample must be in line with combination line of two test sleeves.

B.4.3. Extensometers or linear sensors for shears must be placed in the middle of operating section at a distance from test sleeves, which is 8 (8d) times farther than bar diameter, also the length must be 8 times bigger than bar diameter in order to measure deformation limit.

B.4.4. Estimated maximum loading is determined according to test results of P, H, test sample.

B.4.5. Data record system must be operated for a few seconds before starting the loading. During the testing, loading speed must be constant and must provide a sample failure from 3 minutes to 10 minutes.

B.46. Regarding to tensile strength, deformations must be recorded up to minimum 50% of loading level.

If sample failure occurs in test sleeve or if sample slides around test sleeve, an additional sample from the same batch must be tested.

“Loading - deformation graphic (diagram)" must be created through the loading and measurements recorded with extensometer.

B.5. Processing test results

B.5.1. Strength limit $\sigma_в$, MPa is calculated by using following formula:

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

here, P – failure load, H;
A – the cross section surface (A) of bar is calculated by using following formula:

$$A = \pi d^2/4, \text{ мм}^2.$$

B.5.2. As the ratio of deformation and failure with increase in loads between 0,2P and 0,5P the value of elasticity modulus E_1, MPa, is calculated by using following formula:

$$E_1 = \frac{P_1 - P_2}{(\varepsilon_1 - \varepsilon_2)A}, \quad (Б.2)$$

here, P_1 – failure is the load forming (50±2)% of load, H;
P_2 - failure is the load forming (20±2)% of load, H;
E_1 - deformation corresponding to P_1 load;
E_2 - deformation corresponding to P_2 load.

B.5.3. When loading failure load, relative elongation ε_{fu}, mm/mm, is calculated by using following formula:

$$\varepsilon_{fu} = \frac{P}{E_f A}, \quad (Б.3)$$

Values of characteristics and quantities examined are determined with an accuracy up to 0.001.

Statistically processing test results is carried out according to requirements in GOST 8.207 standard.

B.6. Test report

Test report must include followings:

- Information about samples specified in sample selection report;
- Testing date;
- Information of test conditions;
- Geometrical characteristics of each sample;
- Values of characteristics measured for each sample;
- The values of each sample characteristic determined in processing of test results;
- Averaged values of characteristics and results of statistically processing;
- "Loading - deformation diagram (graphic) of each sample;
- Information of responsible expert for testing and their signatures.

ANNEX "C" (information - for reference) Compression test method

C.1. General provisions

This method determines the requirements in relation to performance of compression tests of composite polymer reinforcement in order to determine strength limit.

This method depends on sample failure by implementing axial compression loads.
This method including changes and additional operations considers the main provisions of GOST 4651 standard.

- Failure test of sample must be carried out for allowable operation section;
- The part of sample among test sleeves, where test machine holds the samples. is considered as an operation section;
- Tangent and radial elongation impacts of test sleeves on sample failure, which occur in transition zone in the direction of the bar, is not considered.

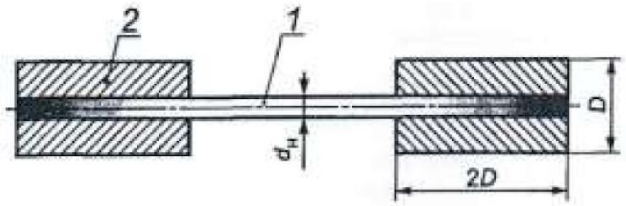
C.2. Samples

C.2.1. Test samples are randomly selected from a batch of composite polymer reinforcements controlled, and this selection is recorded in a report and this report specifies following respects:
- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- batch number;
- Number and size of samples;
- Selection indicators of samples for performance of control;
- Name of responsible for selection of sample.

In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.

Number of samples for tests must be in compliance with requirements in Table 7.

C.2.2. The sample is a piece of bar, of which ends are surrounded with test sleeves (see Figure B.1)



1 – Bar Piece; 2 - Test sleeves
Figure B.1 – Test sample

C.2.3 Total length of sample is determined according to structure of hubs.

C.2.4. The length of operating section between hubs must be 6d.

C.2.5. Before testing, test samples must be stored according to requirements in GOST 12423 standard.

C.3. Equipment (apparatus, devices) and material

C.3.1. Test machine must provide following respects according to GOST 28840 standard:

- For performance of test in relation to control indicators, the loadings exceeding the sample strength;
- Measurement of the distance between the load and cross sections (transverse lines) with maximum 0,50% of error margin.
- 5-100 mm/minute active traverse shear.

C.3.2. Test device in relation to compression of samples consists of guidance hub, which provides the loads on axis of bar, and two test sleeves which are placed on the ends of sample and provides the failure of sample within operating section (see Figure B.2).

Figure B.2. – Compression Test Device of Samples

C.4. Performance of test

C.4.1. Test conditions must be in compliance with sub-parts 3.15 in GOST 15150 standard.

C.4.2. Sample is placed into test machine.

C.4.3. Measurement unit is operated and drive of test machine adjusted to test regime. Recommended speed is 5/15 mm/minute. Load must not cause impacts on sample, but it must be gradually implemented.

C.4.4. Loading must be continued until sample shows failure. If failure occurs outside operating section, an additional sample from the same batch must be tested.

C.4.5. Failure load is determined with an accuracy up to 0,001.

C.5. Processing test results

C.5.1. Strength limit $\sigma_{вс}$ MPa is calculated by using following formula:

$$\sigma_{вс} = \frac{4P}{\pi d^2}, \qquad (B.1)$$

here, P - failure load, H;
d – Nominal diameter, mm.

The values of characteristics and quantities are sensitively determined with an accuracy up to 0.001.

Statistically processing test results must be carried out according to requirements in GOST 8.207 standard.

C.6. Test report

Test report must include followings:

- Information about samples specified in sample selection report;
- Testing date;
- Information of test conditions;
- Geometrical characteristics of each sample;
- Values of characteristics measured for each sample;
- The values of each sample characteristic determined in processing of test results;
- Averaged values of characteristics and results of statistically processing;
- "Loading - deformation diagram (graphic) of each sample;
- Information of responsible expert for testing and their signatures.

ANNEX “D” (information - for reference) Crosscut test method

D.1. General Provisions

This method determines the requirements in relation to composite polymer reinforcement tests in order to tensile strength when performing crosscut of bar in cross direction of fibers.

This method depends on implementation of cutting load on sample by directly using double cut.

D.2. Samples

D.2.1. Test samples are randomly selected from a batch of composite polymer reinforcements controlled, and this selection is recorded in a report and this report specifies following respects:

- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- batch number;
- Number and size of samples;
- Selection indicators of samples for performance of control;
- Name of responsible for selection of sample.

In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.

Number of samples for tests must be in compliance with requirements in Table 7.

D.2.2. The sample for testing is a bar, of which length is specified according to structure of test devices without giving importance to diameter, but length must not be less than 250 mm.

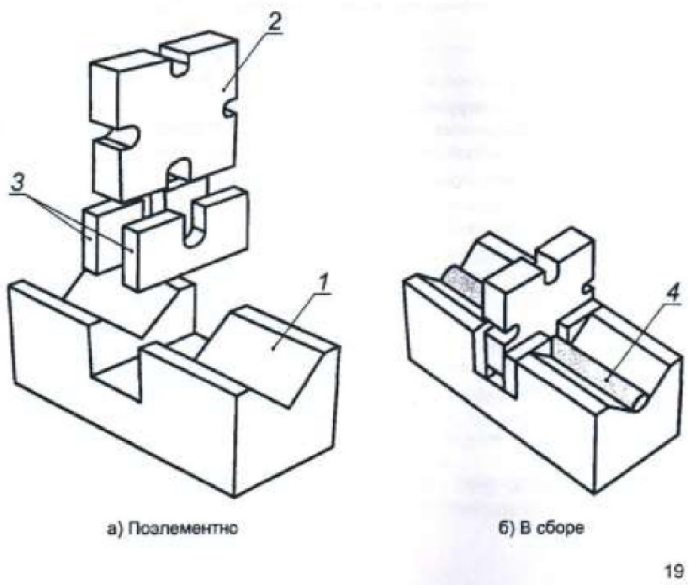
D.2.3. Before testing, test samples must be stored according to GOST 12423 standard.

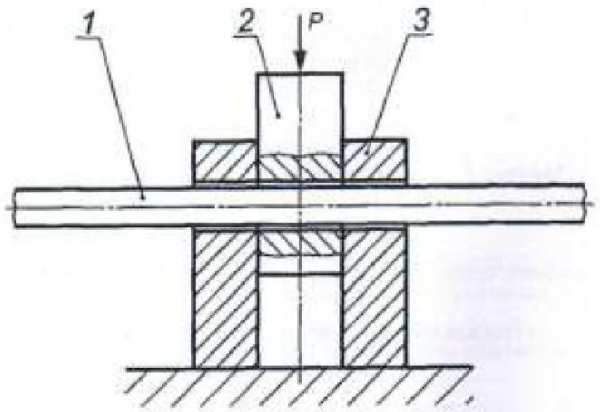
D.3. Equipment (apparatus) and materials

D.3.1. Test machine must provide followings according to GOST 28840 standard:

- the loads exceeding the test sample strength for control indicators;

- Measurement of the distance between the load and cross sections (transverse lines) with maximum 0,50% of error margin.
- 5-100 mm/minute active traverse shear.

D.3.2. Test device consists of sample holder with V-shape (see Figure D.1), a rectangular canal for fixing upper and lower blades, the canals with U-shape for location of samples or passing holes (see Figure G.2) (holes are calibrated according to sample diameters). D.3.3. Total distance between one upper blade and two lower blades must be at least 0,25 mm. 1- Holder; 2 – upper blade; 3 – lower blade; 4 – test sample. Figure D.1 – Crosscut Test Device for sample	
	a) Pieces (elements, objects) b) Mounted



1 — опытный образец; 2 — верхний нож; 3 — нижние ножи

Рисунок Г.2 — Схема приспособления с проходными отверстиями

1 – Test sample, 2 – upper blade; 3 – lower blade

Figure D2 – Devices with passing holes

D4 Performance of tests

D.4.1. Test conditions must be in compliance with sub-part 3.15 of GOST 15150.

D.4.2. Sample is placed in the centre of test device and mounted to test device.

D.4.3. The surface of upper blade must contact with load application unit of test machine, there must no space.

D.4.4. Measurement unit is operated and drive of test machine is adjusted to test regime. Recommended speed is 5-15 mm/minute. Load must not cause impacts on sample, but it must be gradually implemented.

D.4.5. Sample must be close along the vertical edges and must be cut with blades simultaneously.

D.4.6. For reduction of friction on blade edges, the surfaces may be grinded, polished or covered with a thin grease layer.

D.4.7. Loading must be continued until failure occurs.

D.4.8. Failure load is determined with an accuracy up to 0,001.

D.4.9. Shear of press plates and vertical shear of the bar (sample) are measured with electronic sensors with an accuracy of 0,01 mm.

D.5. Processing test results

Tensile limit in crosscut τ_{sh}, MPa is calculated and determined by using following formula:

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

Here, P – failure load, N;

A – Area of crosscut surface for sample, $A = \pi d^2/4$, mm^2

Statistically processing of test results is carried out according to requirements of GOST 8.207.

D.6. Rest report

Test report must include followings:

- Information about samples specified in sample selection report;
- Testing date;
- Information of test conditions;
- Geometrical characteristics of each sample;
- Test results;
- Values of characteristics measured for each sample;
- The values of each sample characteristic determined in processing of test results;
- Averaged values of characteristics and results of statistically processing;
- View of failure and characteristics for each sample (characteristic, nature)
- Information of responsible expert for testing and their signatures.

ANNEX “E” (information - for reference) Strength limit for adhesion to concrete

E.1. General Provisions

This method is related to requirements about strength limit of composite polymer reinforcement during adhesion to concrete, and sample is axially pulled and removed from the cube or the sample is subject to bending test.

This method depends on shear stresses without considering failure point of sample (failure in the bar or failure in adhesion points to concrete), when the sample is subject to tensions until it gives failure under maximum loads.

E.2. Samples

E.2.1. Test samples are randomly selected from a batch of composite polymer reinforcements controlled, and this selection is recorded in a report and this report specifies following respects:

- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- batch number;
- Number and size of samples;
- Selection indicators of samples for performance of control;
- Name of responsible for selection of sample.

In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.

Number of samples for tests must be in compliance with requirements in Table 7.

E.2.2. For the performance of tests, where cubes are axially pulled and removed, the samples consist of concrete cubes with vertical and horizontal composite polymer reinforcement bars as well as test sleeve in the centre of concrete. (see Figure E.1)

Total length of samples that are selected for testing:

- Application conditions for adding into concrete;
- Conditions for placement of sample onto test machine;
- are determined according to structure of test sleeves.

Table E.1 (D.1) - sizes of test samples, mm

Nominal diameter of composite polymer reinforcement	Edge size of concrete cube	Length of composite polymer reinforcement in adhesion to concrete
≤ 10	100	*5d*
Between 12 and18	150	
» 20 » 30	200	

E.2.3. The part of the bar that is inserted into concrete outside adhesion area is protected with polyvinylchloride journal bearing or a pipe.

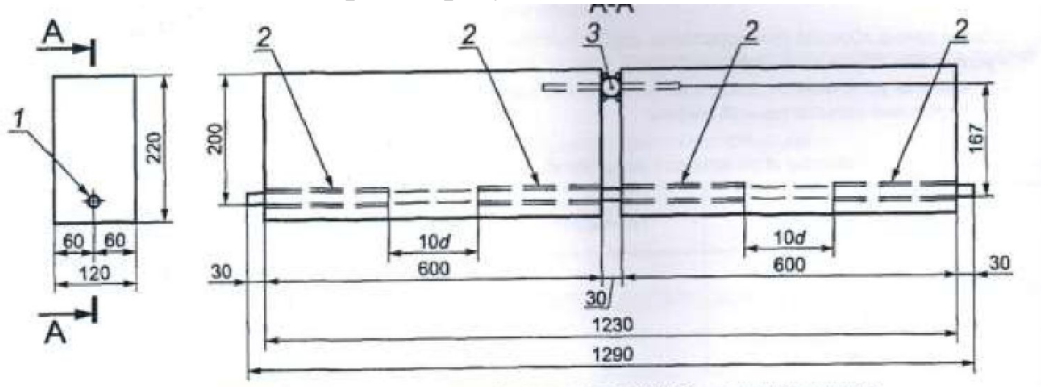
E.2.4. The length of the edges, surface and vertical bar of sample must be at least 200 mm, thickness must be 20 mm; it must be covered with a steel square plate that is used as a bearing surface and prevents the impacts on concrete cube. There must be a hole in the centre of plate, which will be necessary for the bar.

E.2.5. The samples for testing (see E.2) consist of two parts; one of them is connected to the bar in extended zone, another is connected to two cast pieces and a cylinder hinge between them for compressed zone. In the middle of each part, composite polymer reinforcement has an area for adhesion to concrete; out of this area, it has an area inside of polyvinyl pipe.

Cross sections of test samples are 120 x 220 mm and square shape with a total length 1230 mm; length of parts (half pieces) of sample is 600 mm, the distance between the parts is 30 mm. The distance between the axis of sample bar and the axis of steel cylinder is 167 mm.

Рисунок Д.1 — Схема установки АКП в бетон куба

Figure D1 – Insertion of composite polymer reinforcement into the concrete cube



1 — стержень; 2 — поливинилхлоридный вкладыш или трубка; 3 — стальной цилиндр

Рисунок Д.2 — Схема установки АКП в бетон при испытаниях балки на изгиб

1 – bar; 2 – polyvinylchloride journal bearing or pipe; 3 – steel cylinder

Figure D.2 – Insertion of composite polymer reinforcement into concrete during strength test

E.2.6. It is recommended to use following method for pouring concrete into the form:

- Concrete mixture is poured in four layers with the same thickness, and each layer must be supported with a metal bar having a diameter of 16 mm;

- Following the compression of upper layer, surface is finished, evaporation is prevented to avoid moisture loss; the same procedure is carried out in the area where vertical bar is connected to concrete.

E.2.7. Following conditions are valid for concrete:
- size of filling material 20 – 25 mm;
- mobility mark of concrete mixture - PZ;
- Class of concrete for compression strength – B25.

E.2.8. Compression strength of concrete is determined according to cubes of which edges is 100 mm and number is at least 3. Implementation on samples are carried out at least 24 hours later as of their preparation. Samples are protected under normal conditions. Samples' age is 28 days and nights for testing.

E.2.9. Before testing, samples are stored according to GOST 12423 standard.

E.3. Devices (apparatus) and materials

E.3.1. Test machine must provide following respects according to GOST 28840 standard:
- For performance of test in relation to control indicators, the loadings exceeding the sample strength;
- Measurement of the distance between the load and cross sections (transverse lines) with maximum 0,50% of error margin.
- 5-100 mm/minute active traverse shear.

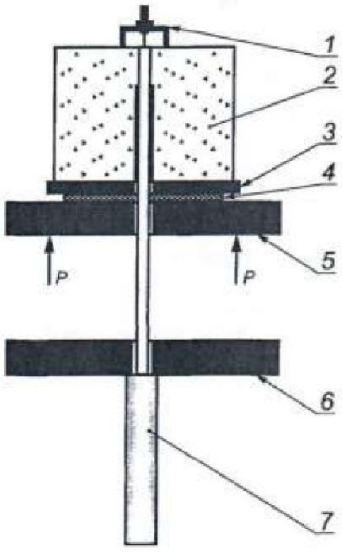
E.3.2. In order to measure the shears of composite polymer reinforcement in concrete, linear shear sensors, analogue and numeric indicators up to 0,01 mm accuracy are used.

E.3.3. Followings are necessary to prepare test samples:

- Waterproof metal molds that allow proper concrete cubes with necessary holes for insertion of composite, molds are easy-removable to prevent the damages on bars;
- Test sleeves in accordance with Annex “B” Table B.1.

E.4.1. Test conditions must be in compliance with sub-part 3.15 of GOST 15150 standard.

E.4.2. In order to axially remove sample for test, support plate on free end of bar is placed in contact with movable traverse of test machine (see Figure D.3.).



1 — измеритель проскальзывания на свободном конце стержня; *2* — образец; *3* — опорная плита; *4* — мягкая прокладка; *5* — подвижная траверса испытательной машины; *6* — неподвижная траверса испытательной машины; *7* — испытательная муфта

Рисунок Д.3 — Схема испытания образца при осевом выдергивании из куба

1 – Measurement device for shear of free end of bar; 2 – sample; 3 – support plate; 4 – soft base;
5 – movable traverse of test machine; 6 – stable traverse of test machine; 7 – Test sleeve.

Figure D.3 – Test diagram for axial removal of sample from cube

E.4.3. Bearing block must be on support, and this support transmits the reaction to strength measurement unit of test machine.

E.4.4. Outer part of bar must pass through the joint of bearing block and support plate; test sleeve must be placed onto stable traverse or into clamps of test machine.

E.4.5. Shear measurement device is placed onto free end of bar.

E.4.6. Upper surface of stable traverse or the distance of test machine clamps up to the surface with shear measurement device is measured with an accuracy up to ± 0,01 mm.

E.4.7. Measurement data is not acceptable: if bar is broken or if bar dislocates in test sleeve before it dislocates in concrete or if implemented load is reduced due to cracks of concrete, then a new sample from the same batch is tested again.

E.4.8. If concrete is cracked at the end of tests, timbers must be used to increase the size of concrete cube edges or continue to carry out tests.

E.4.9. Bending test is carried out according to test schema specified in Figure D.4. Shear measurement device is placed onto edge of timber and onto end of bar.

Рисунок Д.4 — Схема испытания образца изгибом балки

Figure D.4 – Sample Testing by bending the timber

E.4.10. The load implemented and the values shown by measurement device are recorded with the steps equivalent to 10% of estimated load causing the shear of bar as 0,25 mm. In each step of load, test samples are held for 15 seconds and the values shown by measurement device are considered. Then, loads are implemented until sample breaks off or concrete is broken or bar shows a shear of 2.5 mm; load and shear is sensitively recorded with an accuracy of ± 0,01 mm.

E.4.11. The loads on sample are implemented at a speed maximum 20kH/minute.

E.5. Processing test results

E.5.1. For each sample, "adhesion - shear" diagrams are created.

E.5.2. Averaged tensions of adhesion causing the shear of free end of bar at 0,05; 0,10 and 0,25 mm and the maximum tension of adhesion are determined.

E.5.3. Tension of adhesion to concrete τ_r MPa, is calculated by using following formula for axial removal from cube:

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

here, P – the load implemented, H;

c – nominal length of bar round, $c = \pi d$, мм;

L_{fb} - depth of bar in the concrete, mm.

E.5.4. In each step of load implemented, shear value of free end of bar is calculated as difference between the values from measurement device and elastic strain of bar.

E.5.5. Elastic strain *S*, mm, is calculated and determined by using following formula:

$$S = \frac{PL}{E_f A}, \quad (Д.2)$$

Here, P - load, H;
L – Distance between from upper surface of stable traverse or clamps of test machine to free end of bar with measurement device, mm.
E_f - elasticity modulus, MPa;
A – cross section surface, $A = \pi d^2/4$, mm^2.

E.5.6. Tension of adhesion to concrete τ_r MPa, is calculated by using following formula for bending test of timber:

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

E.5.7. Axial thrust on the bar N_x, H, is calculated in the middle of timber by using following formula:

$$N_x = \frac{M}{z}, \quad (Д.4)$$

here M - common moment in the area dividing the timber, H mm;
z - the arm of double dividing the timber that is equivalent to distance from axis of bar to axis of steel cylinder in compressed area, mm.

E.6. Test report

Test report must include followings:

- Information about samples specified in sample selection report;
- Testing date;
- Information of test conditions;
- Geometrical characteristics of each sample;
- Information of concrete; combination and mobility of concrete mixture, information about compression strength of "28-day and night" concrete samples;
- Values of characteristics measured for each sample;
- Information of sample bars for testing: limit of tensile strength and elasticity modulus, size of test samples, length of bar in contact with concrete;
- The values of various characteristics for each test sample
- The values of each sample characteristic determined in processing of test results;
- Averaged values of characteristics and results of statistically processing;
- "Tension in adhesion" diagram (graphic) of each sample;
- Information of responsible expert for testing and their signatures.

ANNEX F (information - for reference) Fast determination of resistance to alkalis

F.1. General Provisions

This method is to determine the resistance of composite polymer reinforcements to alkalis by submerging them into alkali solution; external impacts of alkali environment on the bar and tension test, and the strength limit of bar in adhesion to concrete.

F.2. Basic of method

Method predicts a testing according to two schemas.

- "A" schema – in this system, samples are submerged into alkali solution and then subject to tension until they show failure. The parameters controlled - pH level, temperature of alkali solution, submersion time;
- "B" schema – in this system, samples - one end with test sleeve for connection to test machine, other end in alkali solution - are combined with concrete and then removed from concrete.
- The parameters controlled - pH level, temperature of alkali solution, submersion time.

F.3. Samples

F.3.1. Test samples are randomly selected from a batch of composite polymer reinforcements controlled, and this selection is recorded in a report and this report specifies following respects:

- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- batch number;
- Number and size of samples;
- Selection indicators of samples for performance of control;
- Name of responsible for selection of sample.

In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.

Number of samples for tests must be in compliance with requirements in Table 7.

F.3.2. According to "A" schema, total length of samples is in compliance with paragraph B.2.3 of Annex "B".

F.3.3. According to “B” schema, total length of samples is in compliance with paragraph D.2.3 of Annex "D".

F.3.4. Concrete mixture is poured according to paragraph D.2.6 of Annex "D".

F.3.5. Concrete requirements is specified in paragraphs D.2.7 and D.2.8 of Annex "D".

F.3.6. According to A and B schemas, lateral surfaces of samples must be covered with epoxy resin layer to prevent the alkali solution reaching bar mass.

F.3.7. Before testing, test samples are stored according to GOST 12423 standard.

F.4. Devices (apparatus) and materials

F.4.1. Test machine must provide following respects according to GOST 28840 standard:

- For performance of test in relation to control indicators, the loadings exceeding the sample strength;
- Measurement of the distance between the load and cross sections (transverse lines) with maximum 0,50% of error margin.
- 5-100 mm/minute active traverse shear.

F.4.2. Alkali solution models zero phase of concrete and contains: 80 g NaOH and 22.4 gr. KOH: E42 alkali solution in a (1) liter of demineralized water.

F.4.3. pH value of alkali solution must be 12,6 -13. Before and during tests, solution must be held in closed container to prevent the impacts of CO_2, air and evaporation.

F.4.4. Test sleeves are specified in Table B.1 of Annex "B".

F.5. Performance of tests

F.5.1. According to "A" schema, samples are tested in following order:

- before submerging in alkali solution, sample must be dried at temperature (100 ± 2) °C until it reaches stable mass m_0.
- Samples are submerged in alkali (60 ± 3) °C stable alkali solution for 30 days and nights; but whole body of sample is not submerged into alkali solution, only operating section between test sleeves is submerged.
- After this period of time, sample is removed from alkali solution and then washed with demineralized water, they are dried at (100 ± 2) °C for at least 4 hours and then weighted (m_1)
- Test sleeves are placed onto bars and they are subject to failure test until they are completely broken according to Annex B.

F.5.2. According to “B” Schema, samples are tested in following order:

- samples are submerged into (60 ± 3) °C stable alkali solution for 30 days and nights, and whole body of sample is not submerged into alkali solution, but the part of sample in contact with concrete is submerged;
- Then, sample is removed from alkali solution;
- Test sleeve that provides the connection of sample to test machine is installed onto the one end of sample, second end of sample (the end submerged into alkali solution) is inserted into the concrete according to paragraphs D.2.3., D.2.4. of Annex "D".
- After waiting for the hardening of concrete for 28 days and nights, sample is placed onto test machine according to schema shown in Figure D.3.
- Tests are carried out according to D.4.2, D.4.3, D.4.4, D.4.6, D.4.8, D.4.10. paragraphs of Annex "D", and strength limit in adhesion to concrete is determined.

F.5.3. According to “A” and “B” variants of alkali solution, pH value is measured before and after testing.

F.5.4. Appearance of sample (changes in color, surface and geometrical sizes) is inspected before and after submerging into alkali solution according to 8.1. and 8.8. paragraphs.

F.5.5. During tension tests, loads on sample is carried out at speed 5-15 mm/minute.

F.5.6. During removal from the cube, loads on sample is carried out at speed maximum 20H/minute or 1mm/minute.

F.5.7. The characteristics of bar material is assessed only after operating section of bars are broken. If break off or shear occurs in the area of test sleeve, data is not acceptable and a new sample from the same batch is tested again.

F.6. Processing test results

F.6.1. Changes in bar mass Δm, % is calculated by using following formula:

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

Here, m_1 – sample mass after submersion into alkali solution, gr;

m_0 – sample initial mass, g;

F.6.2. Strength limit in tension is calculated by using (B.1) formula.

F.6.3. Changes in strength limit in tension is calculated by using following formula:

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

Here, $\tau_{в1}$ - strength limit after submersion into solution, MPa ;

$\tau_в$ - tensile strength limit in initial circumstance (output), Mpa.

Statistically processing tests results is carried out according to requirements of GOST 8.207 standard.

F.7. Test tutanağı (raporu)

Test report must include followings:

- Information about samples specified in sample selection report;
- Testing date;
- Information of test conditions;
- Geometrical characteristics of each sample;
- Values of characteristics measured for each sample;
- The values of each sample characteristic determined in processing of test results;
- Averaged values of characteristics and results of statistically processing;
- View of failure and characteristics (character, nature) for each sample;
- Information of responsible expert for testing and their signatures.

Annex “G” (information, for reference) Test method for determination of maximum operating temperature

G.1. General Provisions

This method determines the initial temperature causing the softening of composite polymer reinforcement according to thermo-mechanical tests.

G.2. Base of method

This method depends on;
- the thermo-mechanical diagram analysis which is obtained when the sample are bended with three-point transverse bending up to predetermined bending value and when bended sample is heated in heating cell, and
- recording the changes in load as long as increase in heating degree.

Bending strength of sample decreases as long as heating degree increases. This occurs because of shear stress of short bended sample and decrease in strength of composite polymer matrix. Speed of changes in sample strength becomes maximum when sample turns into twisted shape from glass shape, in other words, it starts to soften.

In differential-thermal analysis of diagram which specified that bending strength of sample during test depends on heat level (temperature), the heat level (temperature) starting to soften the matrix is determined.

G.3. Samples

G.3.1. Test samples are randomly selected from a batch of composite polymer reinforcements controlled, and this selection is recorded in a report and this report specifies following respects:
- Manufacture company - enterprise;
- Mandatory marks (symbols);
- Type of fiber and binding material;
- Manufacture date;
- batch number;
- Number and size of samples;
- Selection indicators of samples for performance of control;
- Name of responsible for selection of sample.

In the selection of composite polymer reinforcement samples, deformation, undesired temperatures, ultraviolet lights and changes in material characteristics, and other environmental impacts must be avoided.
Number of samples for tests must be in compliance with requirements in Table 7.

G.3.2. The length of test samples must be 12*d*. Length of sample operating section must be limited with 9*d* ± 2 mm.

G.3.3. Before testing, samples are stored according to GOST 12423 standard.

G.4. Devices (apparatus) and materials

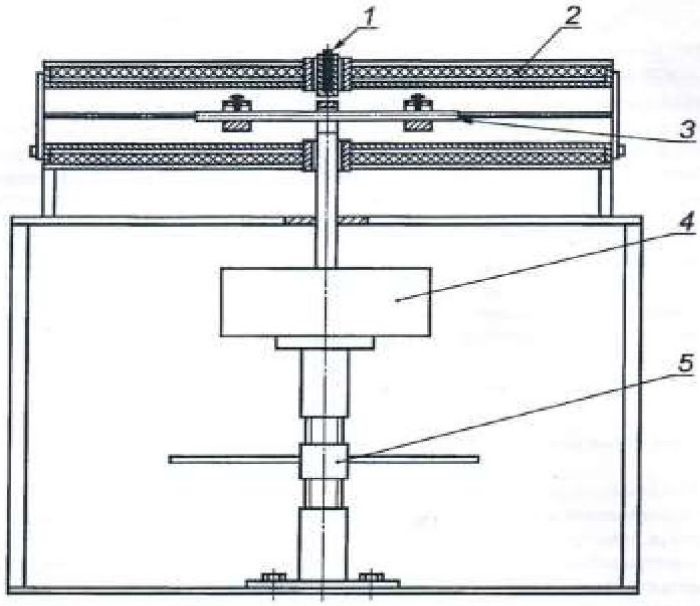
G.4.1. Test machine must provide following respects according to GOST 28840 standard:

- For performance of test in relation to control indicators, the loadings exceeding the sample strength;
- Measurement of the distance between the load and cross sections (transverse lines) with maximum 0,50% of error margin.
- 5-100 mm/minute active traverse shear.

G.4.2. For testing samples, the equipment shown in Figure F.1 must be used.

G.4.3. This equipment consists of followings:
- heating cell (chamber) that is mounted onto the base and provides the heating of sample up to 200 °C;
- loading mechanism;
- power sensor having maximum 0,5% error margin;
- heat sensor having maximum 1% error margin.

This equipment must be equipped with heating speed tools, which provides the increase in temperatures by (1,0 ±0,2)°C/minute, and programmed-measurement complex which is necessary for recording and processing test results.



1 — датчик измерения температуры; *2* — нагревательная камера; *3* — образец; *4* — датчик измерения силы; *5* — нагружающий механизм

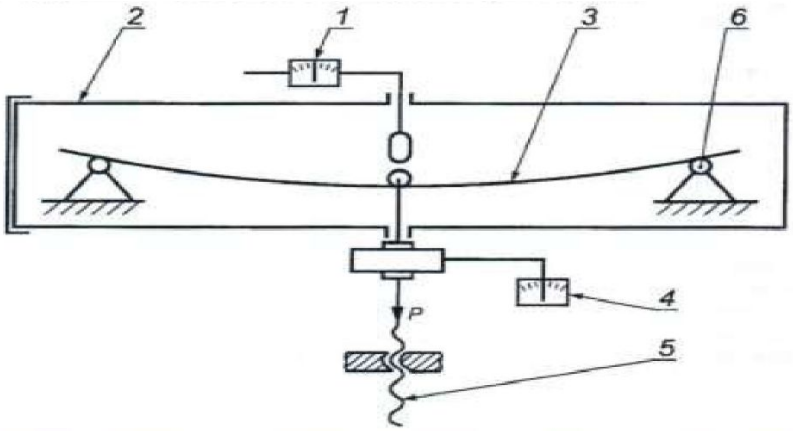
Рисунок Ж.1 — Устройство для термомеханических испытаний

1 – heat level (temperature) measurement sensor; 2 – heating cell (chamber); 3 – sample;
4 – Power measurement sensor;
5 – loading mechanism.

Figure G.1 – Equipment for thermo-mechanical tests

G.4.4. Sample test schema for determination of initial temperature starting to soften the test sample (see Figure G.2):

- Sample (3) with supports (8) is put into heating cell (chamber) (2) that has reached to room temperature;
- Loading end of loading mechanism (5) bends the sample until it reaches to predetermined bending value;
- Heat levels in heating chamber and strength of sample against this heat are recorded and fixed through sensors (6 and 7) during testing;



1 — датчик измерения температуры; 2 — нагревательная камера; 3 — образец; 4 — датчик измерения силы; 5 — нагружающий механизм; 6 — опора

Рисунок Ж.2 — Схема испытания образца при определении температуры начала размягчения опытного образца

1 – heat measurement sensor; 2 – heating cell (chamber); 3 – sample; 4 – power measurement sensor;
5 – heating mechanism; 6 – support

Figure G2 – Sample test schema for determination of initial heat starting to soften the test sample

- Heating chamber is operated with operating regime that provides heating speed = 1 °C/minute, and it reaches a heat level exceeding heat values in the second point of α-pass;
- In the period of heating, the predetermined frequency, head degrees in chamber and traverse bending strength of sample are recorded.

G.5. Testing samples

G.5.1. Test conditions must be in compliance with sub-part 3.15 of GOST 15150.

G.5.2. On the basis of predetermined testing (distance between supports) the loads on sample must form 10% of breaking load. Estimated value of breaking load *P*, H, is determined by using following formula:

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

Here, $l_р$ – length of operating section of sample, mm.

For the samples with round sections *w*.mm^3 value is found out by using following formula:

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

G.5.3. Test equipment is adjusted to a value corresponding to $l_р$ of test base.

G.5.4. Power and heat level (temperature) sensors are adjusted.

G.5.5. Sample is inserted into the device in the manner that compression - pressing end of device can apply the load to centre of sample between the supports.

G.5.6. Thanks to load application mechanism, the sample is bended until applied load equals to specific load mentioned in G.5.2. Load is controlled according to values shown by power measurement sensor.

G.5.7. Sample is held in aforementioned position for at least 5 minutes. Then, heating chamber is operated in operating regime and changes in temperature is observed.

G.5.8. If temperature in heating chamber increases by 1 °C, temperature of mass and power values (T_i, P_i). are recorded in thermo-mechanical diagram.

G.5.9. Records in relation to mass are recorded with maximum 2 °C of discreteness.

G.5.10. After completion of test, sample is removed from heating chamber, heating chamber is left to reach to room temperature.

G.6. Processing test results

G.6.1. When processing test results, thermo-mechanical diagram of each test sample must be examined.

G.6.2. Thanks to test data processing program (for example "Microsoft Excel"), the graphic of sample thermo-mechanical diagram in *P(T)* coordinates is created by using the mass (T_i, P_i).

G.6.3. Approximate location of diagram beginning and operating section limits is visually analyzed on the graphic. When necessary, location of diagram beginning and operating sections can be clarified in the second step of data processing.

G.6.4. Beginning position of thermo-mechanical curve (before starting of matrix softening) is approximately determined by using linear function $P_i = m\,T_i + n$, and *m* and *n* constants of this function are found out thanks to data processing program.

G.6.5. The load P_1 which is determined for each value of mass is found out by using following formula:

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

Here, T_i – heat level (temperature) in the mass, °C;

P_i –effort values in the mass, H;

m and *n* – the values of empiric constant which determine the beginning position of P_{1i} load against the sample under temperature P_{1i} in heating chamber.

G.6.6. Operating section constitutes new data mass (T_i, P_{1i}), which can be approximately determined with sigmoid according to following formula:

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

Here, *a, b, c, d* – empiric constants of sigmoid that approximately determines the experimental data.
In order to find the constants, it is recommended to use the function no. 8011 in "Table Curve Windows v.1.10" program.

G.6.7. Thanks to "Table Curve Windows v.1.10" program, the first and second derivatives of temperature is found out with mathematical function $[P_1(T)]$, and operating section is approximately determined through heat levels T_i on the basis of loads P_{1i} on sample during testing.

G.6.8. The lowest temperature from second derivative of $[P_1(T)]$ function is accepted as T_a, temperature, and numeric values of $P_1(T)$ function and first derivative $\partial P_1/\partial T$ in thermo-mechanical diagrams is found out for this temperature.

G.6.9. The heat level where the second derivative of $[P_1(T)]$ function has the maximum value is accepted as T_{1a} temperature level.

G.6.10. The heat level where the second derivative of $[P_1(T)]$ function has minimum value is accepted as T_c, °C, heat level.

G.6.11.According to T_a, T_{1a} and T_c values, the accuracy of predetermined beginning and operating section limits of thermo-mechanical curve is analyzed, and it is specified if diagram must be processed again.

G.6.12. Maximum operating temperature (limit of operating heat level) $T_з$, °C, is calculated by using following formula:

$$T_a = T_{1\alpha} - \left(\frac{(1 - P_{1\alpha}) \cos(\theta)}{(1 - \sin(\theta))} \right), \quad (Ж.5)$$

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

G.7. Sensitivity of tests

G.7.1. In heat chamber, heat level must be measured with maximum 2 °C error margin.

G.7.2. Traverse bending strength of sample, maximum value of load during the testing must be measured with maximum 0,5% error margin.

G.7.3. The characteristics obtained, constants, other measures and quantities used in interim calculations must be found out with an accuracy up to 0,001.

G.8. Test report

Test report must include followings:

- Information about samples specified in sample selection report;
- Testing date;
- Information of test conditions;
- Test results;
- Values of characteristics measured for each sample;
- The values of each sample characteristic determined in processing of test results;
- Averaged values of characteristics and results of statistically processing;
- Initial thermo-mechanical test diagram of each sample;
- Dependence of the second derivative of certain load for each sample on heat level;
- Information of responsible expert for testing and their signatures.

ANNEX H (information - for reference) PASSPORT FORM

Manufacturer: (name, address, phone, fax)	PASSPORT number
Manufacture date .	
Delivery date	
Mandatory marking of composite polymer reinforcement (symbols)	
Batch number _____	
Weight of batch (mass), kg	
Total length of batch ____ m	
Number of product in packaging ____ pc(s).	
Quality indicators for norms	

Available certificate (certification) or (documentation)
If necessary, other quality indicators for norms,

Date of Issue: "...." .... 20...

Chairman of Laboratory _____ / _____ /
(signature)

Quality Control Department _____ / _____ /
(signature)

Packager _____
(signature)

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