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Composite Physical - Mechanical Properties Of Bazalt Reinforcement And Comparison With Steel Reinforcement And Inspection For Flammability

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Abstract: This article discusses the effectiveness and scope of steel and composite reinforcement, their advantages and disadvantages, as well as a comparison of their main characteristics. Describes tests to determine the combustibility of basalt reinforcement, in order to determine the possibilities of its application.
Keywords: fittings, composites, fiberglass, carbon fiber, basalt-plastic, steel, hot-rolled, reinforced concrete, energy efficiency, cold worked.

Introduction. Currently, the development of all industries, including the construction industry, requires the use of high-quality materials that can compete in the international market. For example, in the construction industry, in some areas of construction, instead of steel reinforcement used in reinforced concrete structures, composite (fiberglass, carbon fiber, basalt plastic) reinforcement can be seen.

As a result of research, we consider the efficiency of using composite reinforcement instead of steel reinforcement used in reinforced concrete structures, their comparative characteristics, analysis of thermal characteristics, as well as possible and impossible cases.

Reinforcement - reinforced concrete receives stresses as a result of working together with concrete in constructions and is used to strengthen stretching zones and to strengthen concrete in compressed zones (columns).

Materials and Methods. Reinforcement elements are divided into rigid (rolled joints, channels, angles) and flexible (individual rods with a smooth and periodic profile, as well as welded or bonded mesh and frames). It is divided into steel reinforcements (for reinforcing reinforced concrete structures), composite (glass fiber, carbon fiber, basalt plastic) and other types [1].

Monolithic reinforced concrete structures of buildings are mainly non-pre-strengthened structural elements. For the calculation of such constructions, A400, A500 classes of periodic profile reinforcements were used to strengthen the element as working reinforcement. According to the constructive considerations for assembly reinforcements, meshes and frames are formed by welding reinforcements of class B500 and Br500 (Br-I).

Made of steel St3sp and St3ps of class A240 with a smooth surface for strengthening the transverse and inclined reinforcing element (with categories of normalized indicators not less than 2 according to GOST 535), as well as for strengthening the periodic profile of classes A400, A500 used, B500 and Br500.

A400 grade hot rolled rebars are produced from 6 to 40 mm, and A500 grade thermomechanical prepared rebars are produced from 10 to 40 mm with a size step of 2 to 4 mm. According to special orders, A400 and A500 reinforcements can be supplied in large sizes (50 mm) and smaller sizes (5,5 - 8 mm), but due to the difficulties in the production of metal rolls in the design practice of reinforced concrete structures, their use is limited in assortment groups [2].

Compared to other types of products, the advantages of steel reinforcement are sufficiently high strength, including resistance to the affected loads, as well as resistance to negative external influences. Do not be afraid of the damage of the reinforcing steel frames during deformation due to significant external influences or deformations. The main thing is to choose reinforcement with the required length, diameter and appropriate profile.

Disadvantages of steel reinforcement: its weight is large, it corrodes during operation, it conducts electricity well, it has high thermal expansion parameters compared to concrete, its length is limited, it is regulated by the requirements of relevant regulatory documents. As a result, after the formation of the steel frame, as a rule, a certain amount of waste remains, which further increases the cost of the built structure and fittings [2].

Composite reinforcement is a reinforcement made of glass, basalt, carbon or aramid fibers impregnated and hardened with a thermoplastic polymer binder. Reinforcements made of glass fibers are made of glass fiber, basalt fiber - basalt-plastic, carbon fiber - carbon fiber. Special ribs are formed on the surface of the composite reinforcement during the production process, or a sand coating is used for interlocking with concrete. Composite reinforcement is widely used in foundations and constructions of buildings and structures, including hydrotechnical structures (road pavements, roadside structural elements, temporary and permanent road construction structures, etc.).

In addition, composite reinforcement has a number of advantages and disadvantages. Advantages: light, highly durable, economical, energy efficient, sound-absorbing, low thermal conductivity, ease of installation, durability. Disadvantages: low strength, lack of plasticity, heat resistance, low modulus of elasticity, high damage, complexity of production, low plasticity [3,4,5].

The main comparative characteristics of metal and basalt reinforcement are presented in Table1.

Table1.

Comparative characteristics of A400, B500C, Br500 composite					
Mechanical properties and applications	**A400**	**B500C**	**Br500**	**composite**	
				fiberglass	**basalt plastic**
Yield strength, N/mm^2	390	500	500	-	-
Temporary resistance to breaking (endurance limit), N/mm^2	590	600	Standardization is not done	1200	1200
Relative elongation, %	Not less than 14 %	2,5%	2,5%	2,2	1,33-1,86
C=3d bending angle in diameter	90^O	180^O	-	does not bend	does not bend
Standard resistance, R_{sn}, MPa	400	500	500	>1000	>1100
Calculation resistance in compression, R_{sc}, N/mm	350	415 (380)	390 (360)	300	300
Calculated tensile strength, R_s, N/mm	350	435	415	600-1000	800-1100
Calculated resistance R_{sc}, N/mm	390	500	-	600-1200 ASP	700-1300 ABP
Application at negative temperatures	Up to 40^O S	Up to 55^O S	Up to 40^O S	Up to 55^O S	Up to 55^O S
use of arc welding in closing cross joints	(35GS) prohibited (25G2S) permitted	allowed	prohibited	prohibited	prohibited
Elastic modulus, Es,MPa	200000	170000	170000	45000	60000
Thermal conductivity	It conducts heat			Heat resistant	
Heat transfer coefficient Vt/(m°C)	46	56	46	0,5	0,36

Tensile strength, *MPa*	480 - 690	480 -690	-	480 - 1600	480 -1600
Coefficient of thermal expansion	11,7	-	11,7	6-10	-
Coefficient of thermal expansion *10-6/S*	11,7	-	11,7	21-23	-
Optimal temperature range	Lower limit from 196 S to 40 S; 350S to 750S upper limit	Lower limit from 150S to 40S; Upper limit up to 600S	Lower limit from 150S to 40S; 350S to 600S upper limit	from -60C to +90C	from -60C to +90C
Term of service, year	80-100		up to 50		
Material	Steel 35GS, 25G2S, 32G2Rps	Steel St3Gps	Steel St3	Fiberglass diameter 13-16	Basalt fiber diameter 10-16 microns is connected with polymer
Connection method	Wiring, welding			Clamps, clamps and wire binding	
Ecological purity	Harmless			Low-hazard material, safety class – 4	
Comparative weight	According to construction standards			According to construction standards	
Electrical conductivity	Conductive			Dielectric	
Resistance to corrosion, acids and alkalis	irresistible			resistant	

Steel fittings belong to the NG1 flammability class. Composite fittings belong to the G1 flammability class, that is, a self-extinguishing material. It has a low heat resistance, but can withstand temperatures of 200º C without losing its physical and mechanical properties. That is, in cases where high-temperature heating is excluded, it is recommended to use glass fiber [6,7,8]. Glass fiber loses its load-bearing properties at 150° C, basalt fiber - basalt-plastic at 300° C (steel fittings operate under the influence of heat up to 500°C).

The flammability group of materials is given in Table 2.

Table 2.

Flammability indicators and groups of materials

Groups of flammability of materials	**Flammability indicators**			
	Steam gas temperature T, °C	**Degree of perturbation by mass sm**	**Degree of perturbation by mass sm, %**	**Specific burn duration tc.г, c**
G 1	135 to (135 also)	65 to (65 also)	20 to	0
G 2	235 to (235 also)	85 to (85 also)	50 to	30 to (30 also)
G 3	450 to (450 also)	85 more than	50 to	300 to (300 also)
G 4	450 more than	85 more than	50 more than	300 more than

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Note. For materials belonging to the G1-G3 flammability groups, the formation of burning solution drops and (or) flammable fragments during testing is not allowed. For materials that are part of the G1-G2 flammability groups, the formation of solution and (or) solution drops during testing is not allowed.

Results and research discussion. During the experimental and experimental work, several tests were carried out on the flammability of the Basalt armature.

1) when the ø 6 mm basalt fixture was kept heated in a muffle oven for 12 minutes to 200°C, the fixture burned 85% of its elasticity property.

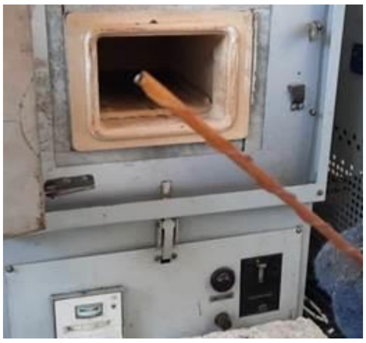
a)  b) 

Figure 1. Preheat a basalt armature of ø 6mm in a Mufeli oven to 2000s.
a) preparing the sample for testing; b) the appearance of the bent sample after testing.

2) ø 8 mm basalt armature butane gas (REG. M4981 UN1950) when held under flame for 30 seconds, the polymer coating on the armature surface overheated and became a soft fiber.

3) ø the polymer coating on the armature surface overheated and turned into a soft fiber while holding the 6mm basalt armature under the butane gas flame at a distance of 30 cm for 15 seconds.

4) when the ø 4mm basalt fixture was kept heated to 50°C for 30 minutes in a mufel oven, the fixture bent and lost stability.

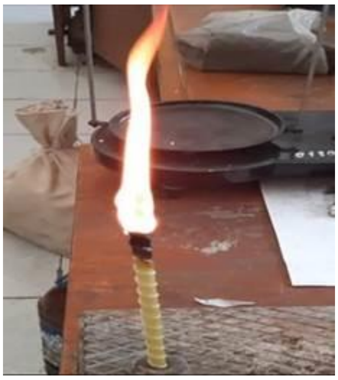
a)  b) 

Figure 2. Testing basalt reinforcement in the flame of butane gas. a) burning basalt fittings;
b) post-Test appearance.

Conclusions. This experiment used certain, widely used, existing methods and tools when performing work. The results of experimental tests showed that during the combustion of butane gas, a loss of strength and hardness of the Basalt armature occurs, its softening and burning of the upper coating [9,10].

It should be noted that basalt-Composite fittings belong to the G1 flammability class, and its top layer cannot be used on the basis of GOST R 57270-2016. For this reason, it is recommended to apply these compositional materials in facilities with low Fire Protection, in environments with sernam, in hydrotechnical facilities, preschools, book storage and archive rooms, as well as rooms with service catalogs and inventory.

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