Prospects for the Use of Composite Materials and Elements in Strengthening Construction Structures

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ABSTRACT

Composite materials are materials that consist of two or more components (phases). The first modern composite material - engineer A.K. Burov was discovered in the late 1930s. For several decades after the end of World War II, the direction associated with the development and use of composite materials in the fields of science and technology developed very intensively.

Keywords: composites, matrix, laminate, monolithic microfibers, aramid, precursor, epoxy, polyester, polyamide, phenolic, resin.

Introduction

Several conditions must be met for a material to be considered a composite. First of all, the material must consist of at least two components. Second, the percentage of each component should not be below a certain value, about 5-10%. Third, the properties of the phases must be significantly different, so the properties of the composite must be different from the properties of the original components [1,2,3].

At the micro level, composites consist of a continuous phase - matrix and a reinforcing phase - filler. The role of the filler is to change the orientation of the properties of the matrix. Composite materials can have a ceramic, metal, or polymer matrix. Polymer matrices have low strength and modulus of elasticity; ceramic matrices have high strength and hardness, but are brittle; metal matrices have average values of strength and deformation [4,5].

The filler is made of strong and hard materials (carbon, glass, aramid, boron, carborundum, alumina, etc.) in the form of particles or fibres. The filler particles are small and approximately equal in size in three dimensions of 10 μm. The length of the filling in the form of fibres is much greater than the diameter. Generally, continuous or short fibres with a small length-to-diameter ratio are used to produce composites. Particles and fibres can be randomly oriented or oriented. If the direction of the filler in the matrix is in one direction, then the composition is uniaxially reinforced; if there are two - then double reinforced [6,7,8].

The main part

A separate class of composites are laminates and hybrids. Laminates are composite materials consisting of several single-sided layers laid in a certain sequence and direction. The number of laminate layers is usually from 4 to 40. Hybrids are composites reinforced with a mixture of different types of fibres, such as glass and carbon fibres.

Fibre-based composites made of monolithic microfibers in a hardening polymer are used to repair and strengthen building structures. Epoxy and polyacrylonitrile resins are often used as matrices. Depending on the type of fibre, composites are divided into composite materials based on carbon fibres (CMFC), aramid fibres (CMFA) and glass fibres (CMFS). In foreign literature, such materials are called FRP (fibre-reinforced polymer) [9,10,11].

Quartz glasses are used in composites based on glass fibres. Glass fibres are divided into 3 types: electronic glass fibre with boric acid and aluminates, which works well in aqueous solutions and have poor resistance to alkaline and acidic aggression; A-glass fibre, durable and harder, but weak against alkalis; AR glass fibre with high zirconium content and high alkali resistance [12-16].

Aramid fibres similar to nylon in structure are produced under different names: Kevlar, Twaron, and Technora. Aramid fibres are anisotropic, have high strength and modulus of elasticity in the transverse direction, and are plastic under the influence of tensile forces and elastic under the influence of compression. Aramid fibres have high hardness, low heat and electrical conductivity.

Table 1.

Conditions of Construction	Composite material types	For coefficient unit γ_{f1}	
		Laminate	For canvas mesh and other materials
In the interior rooms	Carbon composite	0.95	0.9
	Glass composite	0.75	0.7
Open-air	Carbon composite	0.85	0.8
	Glass composite	0.65	0.6
In an aggressive environment	Carbon composite	0.85	0.8
	Glass composite	0.5	0.5

Parameters of composite materials

Carbon fibres are made from a starting material called a precursor. The mechanical properties of fibres depend on the precursor and the degree of carbonization. There are 3 types of precursors: high-modulus extruded pitch fibres, polyacrylonitrile fibres, and cellulose fibres.

The role of the matrix is to transfer the tension between the fibres, protect them from external influences and increase the ease of transportation and installation. The polymer matrix determines the transverse strength and modulus of elasticity of the fibre in compression, shear strength and stress-strain state. Most often, epoxy, polyester, polyamide and phenolic resins act as a matrix.

Figure 1. Parameters of composite materials

Composites are mainly used in the form of canvas to strengthen construction structures by the method of external reinforcement - flexible fabrics with one-sided or two-sided arrangements of fibres. During installation, they are monolithic on the surface of the structure in the adhesive matrix, which ensures the transfer of forces from the structure to the fibre and redistributes them.

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