Composites as a Modern Trend

E P Dorofeev¹, N N Dorofeeva²

¹Senior Lecturer, Department of Architecture and Urban Studies, Institute of Architecture and Design, Pacific National University, 136 Tikhookeanskaya Street, Khabarovsk, 680035, Russia
²Member of the Union of Architects of Russia; Associate Professor, Department of Architecture and Urban Studies, Institute of Architecture and Design, Pacific National University, 136 Tikhookeanskaya Street, Khabarovsk, 680035, Russia

E-mail: 3d1@mail.ru

Abstract. The construction industry is progressing every day, unexplored spaces are expanding, various objects are being built. Composite materials have become a mandatory part of this area. Designing large-scale projects can no longer do without composite. Stable, simple, and also reliable, it has significant advantages in comparison with real materials, which are difficult to change their configuration. Composite materials are used not only in the construction of apartment buildings. It is difficult to imagine a bridge or a dam that does not use a carbon plate. A variety of building components, such as arches or domes, are often formed using composite materials. We believe that this is profitable from the point of view of the industry, as it makes it possible to significantly save our money in the construction of structures, installation, storage and transportation of the composite. Based on these data, we analyzed various types of composite materials, and also revealed their characteristic features in table 1.

1. Composite materials
Composite materials (composites, CM) are artificially created materials consists of two or more heterogeneous and insoluble components, connected by physicochemical bonds.

One component of composite materials is reinforcement or load, which provides the necessary mechanical characteristics of the material, and the other component is a matrix (or binder), which ensures the joint work of reinforcing elements. As a matrix are used polymer, metal, ceramic and carbon materials, depends on the type of composite material that has received a common name.

Hardeners are glass, boron, carbon, organic, mustache and metal threads with high strength and rigidity. During the formation of the composition, the individual properties of the constituent elements of the compositions are effectively used. [1;16]

2. Properties
The properties of composite materials depend on the composition of the components, the quantitative ratio and the strength of the bond between them. By combining the volume content of the components, depending on the purpose, it is possible to obtain materials with the required values of resistance, heat resistance, elastic modulus, or to obtain compositions with the necessary special properties, for example, magnetic, etc.
Composite materials have high specific strength, stiffness, high wear resistance and fatigue strength. Size-stable structures can be made from them. Composite materials are very promising structural materials for many engineering industries.

Composite materials are divided on the basis of the geometry of the filler, its position in the matrix and the nature of the components, the location of the fillers and structure. By the nature of the components, composites are divided into four groups: 1) CMs that contain alloy or metal components; 2) CM, including components of inorganic compounds of oxides, carbides, nitrides, etc.; 3) CM, consisting of non-metallic elements, carbon, boron, etc.; 4) CM-containing components of organic compounds (epoxy, polyester, phenolic and other resins). [1]

Composites are structurally divided into several main classes: fibrous, layered, dispersion-solid, solid-dispersion and nano-composite. Fiber composites reinforced with fibers or mustache. The mechanical properties of the composite may vary depending on the orientation of the size and concentration of the fibers. In addition, fiber reinforcement can be used to determine material anisotropy by properties. By adding conductive fibers, electrical conductivity can be imparted to the material along a predetermined axis. In the case of layered composites, the matrix and filler are arranged in layers. [1]

3. Polymer composite materials
Polymer composite materials are materials in which the polymeric material serves as a matrix. Their application gives a significant economic effect. The formation of parts from polymer composite materials can be achieved by both methods inherent in the molding of polymer products, and by special methods (winding, etc.) inherent in this class of materials: 1) Fiberglass is a polymer composite material reinforced with glass fibers cast from molten inorganic glass. Thermosetting synthetic resins, as well as thermoplastic polymers. [4] Fiberglass rolled (Figure 1) [2] is used to cover the insulating layer of pipes located outside and inside the premises, and can be used at temperatures from -40 to +60. fiberglass plate (Figure 2) [3], due to the light transmission of 92%, is actively used for roofing greenhouses and making canopies. [4]

These materials have a sufficiently high strength, low thermal conductivity, high electrical insulation properties, and transparency for radio waves. fiberglass - cheap materials from a polymer composite material. Their use is justified in serial and mass production, shipbuilding, electronics, construction, in the manufacture of window frames for double-glazed windows, in automobile and railway transport, etc. 2) Carbon fiber reinforced plastics (Figure 3) [4] are compositions of a polymer matrix and hardeners in the form of carbon fibers (carbon fibers). Carbon fibers are obtained from synthetic and natural fibers based on cellulose, acrylonitrile copolymers, etc. Depending on the processing mode and feedstock, the obtained carbon fiber has a different structure. [4]
Figure 3. Carbon fiber.

For the production of carbon fiber, the same arrays are used as for fiberglass. The main advantages of carbon plastics in comparison with fiberglass are their low density and higher modulus of elasticity. Carbon fibers are very lightweight and durable. Carbon fiber and carbon fiber have almost zero linear expansion coefficient.

Carbon fiber can be used to support the building in an earthquake. As an earthquake-resistant component, the designer Kengo Kuma used carbon fiber ropes (Figure 5) [10], thrown over the structure (Figure 4) [10]. Modern technology under the name Cabkoma Strand Rod is developed by the Japanese company Komatsu Seiren. The substance is a composite based on thermoplastic and carbon fiber. Thermoplastic polymer is used as a binder, and carbon fiber works as a reinforcing component in the structure. This technique allows to get ropes 5 times lighter than metal of the same hardness. [10]

Figure 4. A fortified building with earthquake-resistant ropes.
Figure 5. A fortified building with earthquake-resistant ropes.

All carbon plastics conduct electricity well, have a black color, which somewhat limits their range. They are used in aviation, rocket science, mechanical engineering, space technology, medical technology, prosthetics, as well as in the production of bicycles and other sports equipment. 3) Boroplastics (Figure 6) [4] is a composition of a polymer binder and fibers that strengthen boron. Modified epoxy and polyamide binders are used for obtain boron networks. Fibers can be in the form of monofilaments or in the form of auxiliary woven bundles of glass fibers or in the form of strips in which interlacing with other threads cannot be furrowed. [4]

Figure 6. Boroplasic.

Due to the high hardness of the threads, the material has high mechanical properties and high resistance to aggressive conditions. Boron fibers have high compressive, shear, hardness, thermal and electrical conductivity. However, the high fragility of the material complicates their processing and imposes restrictions on the shape of boroplasts. However, the high fragility of the material complicates their processing and imposes restrictions on the shape of boroplasts.

Boroplasts are mainly used in aviation and space technology for the manufacture of parts that are subjected to prolonged loads in an aggressive environment. The cost of boron fibers is very high due to the features of their production technology. [4] 4) Composite reinforcement (Figure 7) [11] - non-metallic rods made of glass, basalt, carbon fibers, impregnated with a thermoset or thermoplastic
polymer binder and cured. in the manufacturing process, ribs are placed or a sand coating is applied to connect with concrete on the plane of the composite reinforcement. [12;16]

![Composite fittings.](image1)

**Figure 7.** Composite fittings.

Composite reinforcement is used for external reinforcement of brick, reinforced concrete and wooden systems. The structure glued with fiber gets extra hardness. In addition, fiber is used in the repair of bearing components made of stone, beams and supports of concrete bridges. [16]

4. **Organoplastics and textolites**

1) Organoplastics (Figure 8) [5] are consists of a composite polymer binder and fillers. Fillers are synthetic organic fibers, less often natural and artificial ones in the form of cables, threads, fabrics, paper, etc. [5]

![Organoplastic.](image2)

**Figure 8.** Organoplastic.

A matrix of epoxy, polyester and phenolic resins, are usually used as well as polyimides in thermosetting organoplastics. Organoplastics have low tensile strength, impact resistance and relatively high dynamic loads, but low compressive and bending strength.

Organoplastics are widely used in automobiles, ships, mechanical engineering, aviation and space technology, electronics, chemical engineering, sports equipment manufacturing, etc. 2) Textolites [6] are laminated plastics reinforced with various fibrous fabrics. Binders in textolites are a wide range of thermosetting and thermoplastic polymers, sometimes inorganic binders based on silicates and phosphates are also used. As a filler, fabrics of a wide variety of fibers are used - chlo-pok, synthetics, glass, carbon, asbestos, basalt, etc. As a result, the properties and use of textolites are diverse. [5;16]
5. Composite materials with a metal matrix
In the production of metal matrix composites (MMC) are used aluminum, magnesium, nickel, copper, etc. Fillers are either high-strength fibers or refractory particles that do not dissolve in the starting metal and have different fineness.

Strengthening metals using fibers, whiskers and wire significantly increases both the strength and heat resistance of the metal. Oxide, boride, carbide, nitride metal fillers and carbon fibers are used. Ceramic and oxide fibers, due to their fragility, do not allow plastic deformation of the material, which leads to significant technological difficulties in the manufacture of products, while the use of more ductile metal fillers allows reforming.

Such composites are obtained by impregnating fiber bundles with molten metals, electrodeposition, mixing the metal with the powder, and then sintering, etc. Reinforced metals are used in rocket science, aircraft, etc. [7]

6. Ceramic composite materials
Ceramic composite materials (CCM) [8] - materials in which the matrix consists of ceramics, and the reinforcement is made of metal or nonmetallic fillers. Strengthening ceramic materials with fibers, as well as dispersed metal and ceramic particles, allows to obtain high-strength composites. [8]

1) Cermets based on transition metal borides are characterized by high heat resistance; they are used for the manufacture of rocket engine parts. Magnetic, porous and contact materials widely used in industry are obtained by powder metallurgy methods. Parts for gas turbines, valves for electric furnaces, and parts for rocket and jet technology are made of high-temperature cermets. Solid and wear-resistant cermets are used for the manufacture of tools and cutting parts.

In addition, cermets are used in separate technological areas - these are fuel cells of nuclear reactors based on uranium oxide, friction materials for brake devices, etc.

2) Carbon ceramic composite materials are promising for use at high temperatures.

The fields of application of composite materials are numerous. In addition to aerospace, rocket and other special branches of technology, they are required in turbine turbine construction, automotive, mining, metallurgy, construction, etc. The scope of these materials is constantly expanding. [8]

7. Fiber concrete
Fiber-concrete is a type of cement concrete in which fiber is fairly evenly distributed as a reinforcing material. Fiber - threads of different lengths used for reinforcing concrete. Fiber concrete is divided into 3 groups, depending on the type of fiber: 1) Fiberglass fiber - used for the manufacture of plastic material. 2) Basalt fiber - the creation of structures of high strength. 3) Carbon fiber - used for areas where chemical reactions are often found. [13]

The advantages of fiber-reinforced concrete include: durability, fire resistance, affordable transportation, increase the life of structures, beauty. Fiber concrete is suitable for both large and small architectural forms. For the decoration of facades, fiberglass concrete is most relevant, since it is light and plastic.

First, a model is made of foam or gypsum. Next, create a form for applying the solution and carry out pneumatic spraying of the first layer of concrete mortar on the form of the matrix. After that, subsequent layers are applied. For the first time in Russia, the material was used to create curvilinear forms of the facade of the Ice Cave in the Zaryadye park (Fig.9) [14; 15].
8. Advantages, disadvantages and application
Since composites are quite effective, application in construction is quite common due to a number of advantages of these materials: 1) Products are very durable, for example, some types of composite materials, glass, can compete with metal in resistance. At the same time, they are flexible and tolerant of various influences. 2) Composites are distinguished by their lightness in comparison with analogues. Lightweight fiberglass beams are much better suited for creating floors in large rooms than metal. The resulting design will not lose strength and quality, but at the same time it requires much less effort during installation work, but it also requires much less effort during installation work. 3) Materials are highly resistant to aggressive environments, so you can create not only internal structures, but also use them for outdoor work, exposure to sunlight, precipitation and sudden temperature changes. 4) Chemical reagents are not afraid of composite materials, so they can be used, for example, for the construction of warehouses where chemical products will be stored. 5) Thanks to new technologies, modern composites are no longer dangerous to fire, do not allow flame to spread, practically do not smoke the environment and do not emit dangerous toxic substances.

Composites have not only advantages, but also disadvantages that prevent their distribution in the construction market. 1) The materials are hygroscopic, that is, they easily absorb moisture, which leads to further destruction. Therefore, they must be further strengthened in the manufacture of watertight protective devices. 2) Some composite materials have low maintainability, which increases the cost of their operation. [9;16; 17]

9. Conclusion
Based on the foregoing, a diagram was compiled (Table 1) to identify the characteristics of composite materials.
### Table 1. Structuring of composite materials.

| Composite Material (CM) | Reinforcement | Matrix | Mode of application | Application area | Geography of application |
|-------------------------|---------------|--------|---------------------|------------------|-------------------------|
| Polymer KM:             | a) glass fibers | Thermosetting Synthetic Resins | a) the manufacture of pools, tanks, containers, etc. | a) construction, shipbuilding, radioelectronics, production of household items, sports equipment | Europe, Asia and North America |
|                         | b) carbon fibers | | b) external reinforcement system, the creation of integral composite parts, power reactors, automotive parts, etc. | | |
|                         | c) a composition of a polymer binder and reinforcing boron | | c) the manufacture of highly loaded parts, as well as reducing their mass | | |
|                         | d) glass, basalt and carbon fibers | | d) foundation slabs, strip foundations, floor reinforcement, blind areas, reinforcing road slopes | | |
| Organoplastics and PCBs | Synthetic fibers | Epoxy, polyester and phenolic resins | The creation of light skin, sound insulation, etc. | Aviation, mechanical engineering, radio electronics | |
| CM with a metal matrix   | High strength fibers, wire, whiskers | Light and heat-resistant metals and alloys | Production of large machine parts, contacts for high-current equipment, bearings, aircraft fire screens, etc. | Engineering, electronics, aviation | |
| Ceramic CM              | Metallic or non-metallic fibers | Powder Combined Matrix | Production of heavily loaded parts of gas turbine engines, heat-shielding | Aviation, mechanical engineering, refractory industry and | |
Based on scheme 1, it was concluded that composite materials are one of the most demanded material resources of modern industrial production. Especially, they are widely and efficiently used in high-tech industries. Products made of composite materials are highly competitive in quality and relatively low price. One of the main advantages of composites is a unique combination of deformation, thermal conductivity, strength, impact resistance, temperature, elasticity, electricity, friction, and other properties that are not inherent in traditional materials.

The trends in this direction have much in common in various sectors of world industry, and thus have a positive effect on the development of the modern world.

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