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FEATURES OF PLASTICS IN MODERN CONSTRUCTION USE

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ABSTRACT

The work is devoted to the study of the plastics features in modern construction use. The plastics classification in modern construction is generalized. This classification includes: the field of building products application, the features of the materials properties and products, a backup group that includes those products that are not included in the previous groups. The classification considered is the basis for choosing the basic materials properties that affect the quality and durability of products. To improve the plastics types in the construction, the Venn diagram is used. The main materials types for manufacturing a product of the "window profile" type are analyzed; the result of the studies is a comparative diagram.

Key words: Classification, Plastics, Properties, Construction, Quality

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1. INTRODUCTION

Polymers are the fourth major class of building material used in civil engineering. Currently, a large number of plastics (several thousand kinds) are produced for a variety of purposes, new types of polymeric materials are constantly appearing and the properties of known plastics are improving. These plastics are increasingly used in civil engineering and can replace virtually all construction materials [1, 2].

Plastics have the necessary complex of valuable physical-chemical and construction-operational properties. Therefore, they belong to a large group of materials with a variety of properties used in construction for finishing, heat and waterproofing and many other special purposes [3-5]. In particular, this is due to the presence of whole valuable properties set in plastics: low density with significant strength, resistance to various aggressive influences, low thermal conductivity, good decorative properties [1, 3]. An essential advantage of plastics is the ease of their processing – the possibility of giving them a variety of forms by casting, pressing, extrusion (extrusion), and also high factory availability of products [6, 7].

Consumption of plastics in construction will continue to grow in the future due to the need to save energy and increase the requirements for thermal insulation. The constant demand for plastics will also be due to the repair and modernization of old buildings.

2. MATERIALS AND METHODS

2.1 Related work

To date, there are a number of works that deal with information about the technology of production and the properties of plastics in order to make it easier to imagine the features of their use in construction.

A review of unconventional sustainable building insulation materials is presented in [8]. Comparative analyses were carried out considering in particular thermal characteristics in terms of thermal conductivity, specific heat and density. Comparative analyzes were conducted taking into account, in particular, the thermal characteristics in terms of thermal conductivity, specific heat capacity and density. Particular attention was paid to researches focused to exploit local materials and even industrial byproducts, since these approaches respectively limit transportation and disposal impacts.

In [9] amyloid fibrils as building blocks for natural and artificial functional materials are reviewed. In paper discuss how amyloid materials exemplify the emergence of function from protein self-assembly at multiple length scales. Authors focus on the connections between mesoscale structure and material function, and demonstrate how the natural examples of functional amyloids illuminate the potential applications for future artificial protein based materials.

In [10] a review of recent research on the use of cellulosic fibers, their fiber fabric reinforced cementitious, geo-polymer and polymer composites in civil engineering are conducted. This review presents a summary of recent development on cellulosic fiber Fabric Reinforced Cementitious (FRC) and Fabric Reinforced Geopolymer (FRG) composites, as well as their cellulosic Fabric Reinforced Polymer (FRP) composites as reinforcements of concrete, masonry and timber structures for civil engineering applications. This paper covers: (1) properties (i.e. chemical composition, microstructure, mechanical properties and cost) of monofilament cellulosic fibers and their comparison with synthetic fibers, the relationship between fiber chemical composition and fibre mechanical properties, parameters affect fiber properties; (2) properties (e.g. fabrication of monofilament fibers to fabrics and structures) of cellulosic fiber fabrics, properties of polymer matrices, and properties (i.e. flexural, tensile, impact, insulation and fire properties) of cellulosic fabric FRP composites; and (3) properties (compressive, flexural and tensile and impact properties) of cellulosic FRC and FRG composites, and the properties of cellulosic FRP composites reinforced concrete, masonry and timber structures. In addition, the degradation mechanisms of cellulosic FRC and FRP are discussed. Furthermore, the durability of FRC, FRG and FRP composites are reviewed and the methods to improve the durability of FRC, FRG and FRP composites from the aspects of fiber modification and matrix modification are reviewed and summarized.

Review on development of polymer mortar composite presented in [11]. This paper focuses on the development of new material based on polymer mortar in respect of construction industry.

2.2 Features of construction and operation properties of plastics

In the construction of plastics are used as building materials, semi-finished products and as building structures [12]. This depends on the properties of the plastics, among which are:

1. Density of plastics – 10 - 2200 kg/m^3. In this case, plastics have high mechanical properties. Thus, plastics with powdery and fibrous fillers have a compressive strength of up to 120 - 200 MPa, and a bending strength of up to 200 MPa. The tensile strength of plastic materials with sheet-shaped fillers reaches 150 MPa, and the glass-fiber anisotropic material is 480 - 950 MPa [13].
2. Plastics are not corroded; they are resistant to the solutions action of weak acids and alkalis. Some plastics, for example from polyethylene, polyisobutylene, polystyrene, polyvinyl chloride, are resistant to even concentrated solutions of acids, salts and alkalis; they are used in the construction of chemical industry enterprises, sewage networks, for insulation of tanks [14].
3. Plastics, as a rule, are poor conductors of heat, their thermal conductivity is approximately 0.23 - 0.8 W / (m- C), and for foam and porous plastics K = 0.06-. 0.028 W / (m- C), in connection with this, plastics are widely used as insulation materials [13].
4. Plastics are well colored in mass and have a smooth, decorative surface.
5. Plastics under the action of long loads, even at normal temperature, exhibit great plastic deformation (creep). Aging and creep (instability of properties in time) is a characteristic feature of polymer composites.

To determine the creep during prolonged load action, one can apply the theory of hereditary elasticity. The theory is based on the Volterra principle [15]. According to the Volterra principle, to solve the problems of elastic aftereffect (creep), the constants of the elasticity theory – instantaneous modules – must be replaced by the corresponding integral operators calculated for a fixed time t. The operators of the elastic modulus and Poisson's ratio, following [15], can be written in the form

$$\overline{E} = E_0 \cdot (1 - k \cdot A_i^*(-\beta)) \qquad 1$$

$$\bar{\mu} = \mu_0 \cdot (1 + r \cdot A_i^*(-\beta)) \quad 2$$

where E_0 – instantaneous value of the elasticity modulus; μ_0 – Poisson's ratio;

r – parameter, defined by the formula [15]:

$$r = \frac{(1 - 2\mu_0) \cdot k}{2\mu_0} \quad 3$$

A_i^* – an integral operator, which can be determined by the formula [15]:

$$A_i^*(-\beta) = \frac{1}{\beta}\left(1 - \exp(-\gamma\beta t^{1+i})\right) \quad 4$$

where γ – parameter equal $\gamma = (1 - i)^{1+i}$; i, β, t – parameters determined from the creep curves.

According to the Volterra theory, the operator shift modulus $\bar{M}$ can be represented as [15]:

$$\bar{M} = \frac{\bar{E}}{2(1 + \bar{\mu})} \quad 5$$

Based on the combination of certain plastics properties, they are distinguished: thermoplastics, elastomers, duroplasts and silicones.

Thermoplastics are synthetic materials that become soft upon heating, and when hardened again they harden. The most commonly used thermoplastics are PVC, PVA, PS, PE. Also the most important thermoplastics are polymethyl methacrylate or acrylic glass (PMMA), polyamide (PA), polycarbonate (PC) and polyisobutylene (P1B) [16, 17].

Elastomers are synthetic materials with elastic properties. They easily change shape; if the voltage is removed, they again take their original form. Elastomers differ from other elastic synthetic materials in that their elasticity, similar to rubber, depends largely on temperature. For example, silicone rubber remains elastic in the temperature range from – 60 to +250 °C [16, 17].

Duroplasts are synthetic materials that do not soften and melt in a hardened state and under strong heating. The most commonly used duroplasts are phenolic resins, urea formaldehyde resins and melamine resins, epoxy resins, unsaturated polyester resins and polyurethanes [16, 17].

Silicones are oily materials, usually painted white or transparent. Silicones belong to a group of synthetic materials that have a composition different from the rest of the plastics, and in which mostly the carbon atoms are replaced by silicon atoms. The properties of silicones depend on the length of their macromolecules and on the degree of their network structure [16, 17].

3. RESULTS AND DISCUSSION

3.1 Investigation of the plastics application field in modern construction

Under the concept of a construction product, we mean the entire range from building materials to structural elements. Today, the development of new materials (composites) for construction, intended for contact with the surrounding sometimes and aggressive environment, is a task of high complexity. At the same time, innovation in construction is also rapidly and widely spread. In order to analyze the plastics application field in construction, it is necessary to consider a generalized classification of the directions of their use Figure 1.

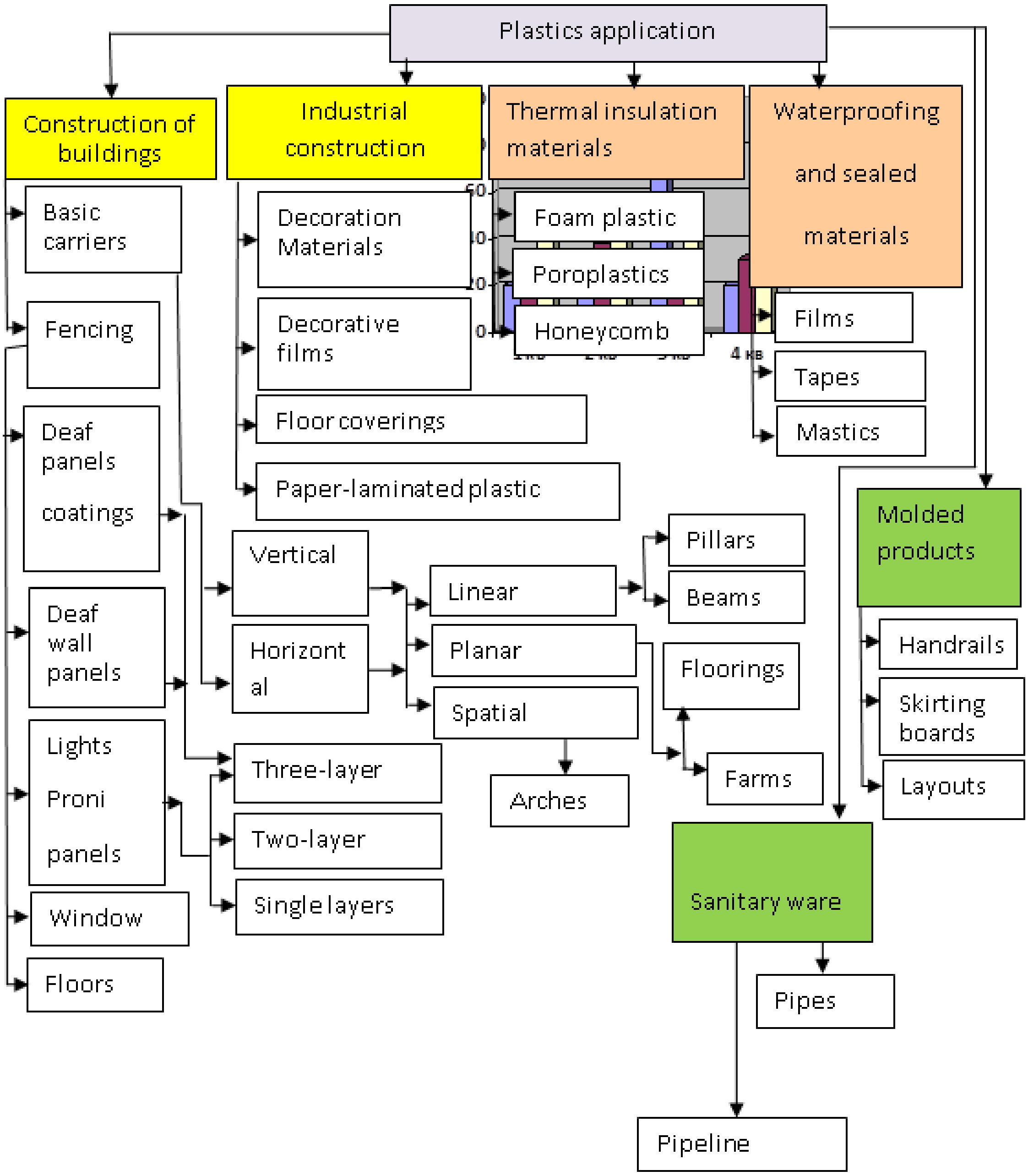


Figure 1 Directions of the plastics in modern construction use

From the data in Figure 1 show that the range of possible plastics applications in modern construction is quite extensive. At the same time, it should be emphasized that in some cases, in particular when considering load-bearing structures, the use of plastics is an additional element that allows achieving the necessary properties of certain structures. A special place among such plastics is occupied by polymer adhesives, as well as polymer concrete, used for the construction of chemically resistant coatings, repairing and strengthening structures of buildings operating under aggressive conditions.

3.2 Classification of polymeric materials in modern construction

Classification of polymer as a result of the studies, a classification of the main plastics types is proposed according to the specifics of the directions applications and properties of the materials themselves. We will describe the proposed classification of plastics in 4 groups:

1st group – by type of application: 1.1 buildings and 1.2 industrial constructions.

1.1.1 The main carriers are: a) fence posts (Polyvinylchloride (PVC)); b) arches, beams, trusses (Polycarbonates (PC), Polymer Cement Concrete (PCC)); c) Light domes (Poly (methyl methacrylate) (PMMA), PC).

1.1.2. Protective structures: a) walls (Honeycomb, Polyvinylcaprolactam (PVCL), PCC); b) doors (Honeycomb, Polyurethane (PUR), PCC); c) windows (profiles) (PUR, Honeycomb, Fiber Reinforced Plastics (FRP), PVC-U, Glassfiber Reinforced Plastic (GRP)).

1.2.1 Finishing materials. 1.2.1.1 Walls: a) washable wallpaper (PVC); b) wall panels (simple and relief) (Polystyrene (PS) (Figure 2a), c) decorative wall panels (PS). 1.2.1.2. Ceiling: ceiling panels (PVC) (Figure 2b). 1.2.1.3 Decorative films (self-adhesive for windows, doors) (PVC, Polyethylene terephthalate (RETE)).

1.2.2 Floor coverings: a) linoleum (PVC, PETE); b) carpet (PUR, PVC); c) sheet floors (PVC); tiles (PVC, Indecumarone, Phenol formaldehyde (PF)); d) paper laminated (PVC).

a) wall tiles

b) ceiling panels

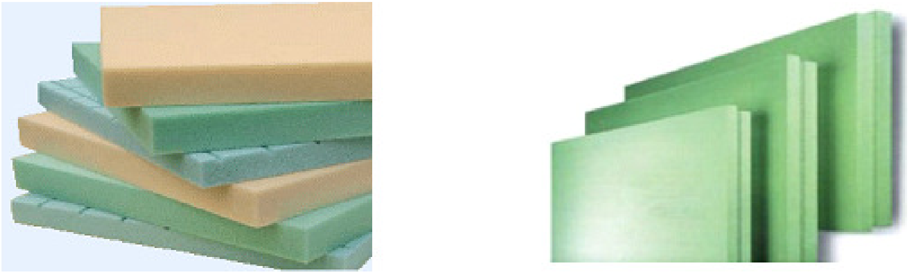
Figure 2 Finishing materials

2nd group – according to the material peculiarity: 2.1 heat-insulating materials and 2.2 waterproofing and sealing materials.

2.2.1.1 Plates or liquid compositions of expandable in-situ packing (Polymeric foam (Figure 3a): Expanded polystyrene (EPS), PVC, Polyurethane foam (PPU); Poroplastics based on: EPS (Figure 3b), PUR, PPU).

2.2.1.2 Thermal insulation of pipelines (PETE).

2.2.2 Waterproofing and sealing materials: a) films and tapes (PETE, Poly (vinyl acetate (PVA), PET), b) mastics (PETE, PUR).



a) plates of foam plastic b) plates made of expanded polystyrene

Figure 3 Thermal insulation materials

3-rd group – by product feature (3.1 molded and 3.2 sanitary ware).

3.1.1 Skirting boards (PUR, PVC) (Figure 4a); 3.1.2 Reiki or siding (PVS) (Figure 4b). 3.1.3 Handrails (PVS) (Figure 3 and Figure 4).

3.2.1 Pipes and piping: a) ventilation, b) smoke, c) water supply, d) sewerage (non-pressure) (Fluoropolymer, PVC, Honeycomb, Low-Density Polyethylene (LDPE), High-Density Polyethylene (HDPE), Polypropylene PP), ABC / PS).

a) plinth b) slats c) handrails

Figure 4 Molded products

4th group – reserve.

4.1.1 Gates, cranes, pumps, membranes; sealing gaskets; cuffs, bellows (Fluoropolymer). 4.1.2 Cable and wire (LDPE, HDPE, and PVC). 4.2.3 Insulation (EPS, PUR).

It is determined that when choosing a plastic for building structures, exploited in a particular aggressive environment, one should be guided by its individual qualities.

Based on the conducted studies of plastics, it was determined that the main properties that determine the quality and durability are: ultimate strength, density, elasticity, thermal conductivity, corrosion resistance and weathering resistance.

So, the density of plastics is 10-2200 kg / m3. Plastics with powder and fiber fillers have a compressive strength of 120-200 MPa and a bending strength of up to 200 MPa. The tensile strength of plastics with fillers of sheet steel can reach 150 MPa, as well as an anisotropic material of glass fibers 480-950 MPa.

As a form of information expression about plastics, the Venn diagram is chosen, one of the graphic organizers types, which allows analysis and synthesis to be performed when two or more objects (items, areas, materials) are examined. The Venn diagram is a tool for working with plastics sets [15]. The diagram shows all possible variants of plural plastics types' intersection. The diagram has a pronounced hierarchical character. The number of dissection levels for different units is different. In Figure 5 represents the Venn diagram, which illustrates the relationship between materials, the areas of their application. Features of plastics and the products themselves.

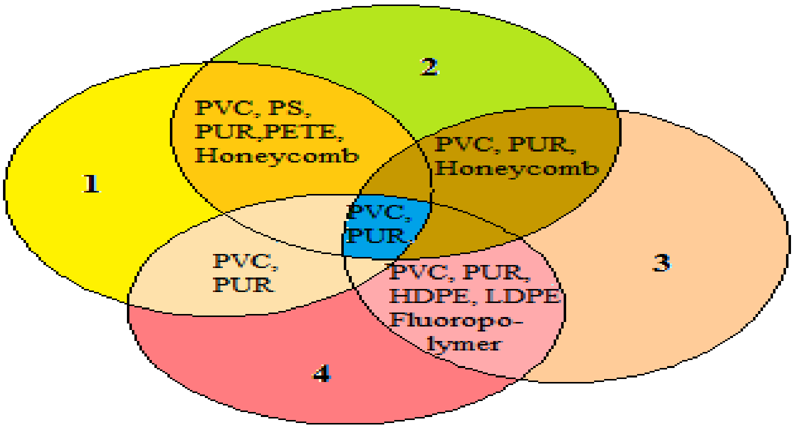


Figure 5 Venn diagram of the relationship between materials, areas of their application

On the basis of Figure 5, it is determined that the most universal are PVC and PUR. Let's analyze between PVC, PUR, which, based on the Venn diagram, are universal and other possible materials types. A product of the "window profile" type was chosen as the experimental sample. That is, we will analyze the properties of existing building materials types.

The main properties and their values are presented in Table. 1

Table 1 Properties of the main building materials types on the example of a product "window profile" types

Property	**Tensile strength (longitudinal) (MPa)**	**Tensile strength (transverse) (MPa)**	**Modulus of elasticity (longitudinal) (GPa)**	**Thermal conductivity (W/m/°C)**	**Linear thermal expansion (xlO^{-6}) (m/m/°C)**
Number property	1	2	3	4	5
FRP	410	69	24	0,3	3,1
GRP	240	50	20,67	0,35	3,3
PVC-U	45	45	2,4	0,2	21
PUR (Thermoplastics)	35	40	2,07	0,21	23,6
Wood	6	4	0,9	0,1	0,94
Aluminum	138	138	69	174	7,2
Steel	207	207	207	52	3,9

The results of the analysis are shown in the diagram in Figure 6.

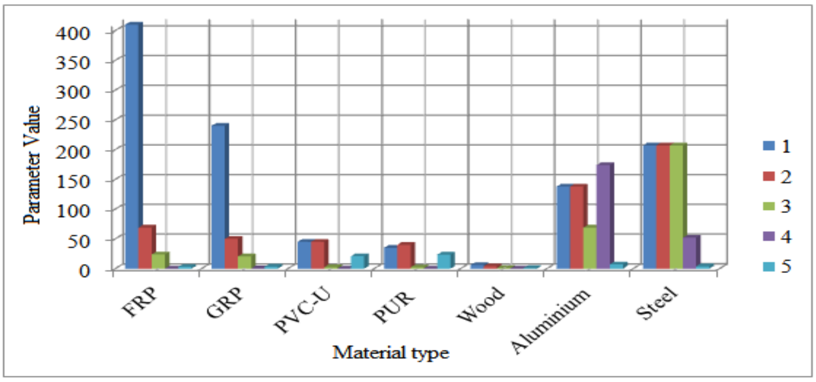


Figure 6 Results of the main building materials types analysis on the example of a product "window profile" types

Thus, proceeding from the diagram it is evident that the most optimal material is steel, however, taking into account the corrosion resistance, this material is in last place. We can also see that the tree has the lowest values. However, plastics have a high resistance to corrosion and resistance to weathering, which will ensure the durability of plastic products, and also makes it possible to use this material for external construction applications. If you take into account the cost of the material, the leader can also be called a plastic product. The proposed classification of plastics in modern construction differs from the existing ones in that it divides plastics into four groups. The first of these groups takes into account the specifics of the application areas, the second and third – the features of the materials and products properties, the fourth – a backup, which includes those products that are not included in the previous groups. In general, this allows you to determine all the main types of plastics.

4. CONCLUSION

As a result of the plastics use in modern construction, the existing range of plastic materials and composites for their use in construction is disclosed. The analysis of possible materials types is carried out. The basic requirements for materials for "products" in construction are determined. As a result of the plastics analysis, the classification of plastics in modern construction is presented, consisting of 4 main groups. The proposed classification became a prerequisite for choosing the main properties of materials that affect the quality and durability. To improve the plastics types in the construction, the Venn diagram is used. The basic materials for the product of the "window profile" types are analyzed and as a consequence, a diagram of the materials ratio and their basic properties is constructed.

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