Building bricks from waste plastic (PET) and crushed basalt as filler

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Abstract

The work examines the properties of composites obtained by heat treatment at ~260-280 oC for 2 hours of PET-crushed basalt mixtures, in which both components are waste from the corresponding industries or household waste. It has been established that, depending on the ratio of components in the initial mixtures, it is possible to obtain building products with properties no worse than ceramic bricks. The maximum value of compressive strength is 18 MPa, bending strength is 3.3 MPa. The samples have low water absorption (≤ 1.4%) and low wear (< 2 mm).

Keywords: PET and basalt mining waste, low-temperature sintering, strength properties.

1. Introduction

Recycling household plastic waste is an important area in the fight against environmental pollution. Waste from polyethylene terephthalate (PET) is the most large-scale. They are collected in sanitary warehouses and, due to the slow decomposition process, are extremely harmful to the environment [1]. One of the directions for processing PET waste is to obtain secondary plastic by melting the waste [2]. Since PET materials have high hardness, and are very resistant to wear and chemicals, as well as shock, breakage, and fire, the synthesis of composite materials consisting of mixtures of PET and inorganic/mineral additives has recently developed [3-8]. Typically, PET-inorganic filler composites have been subject to requirements that suit different types of building materials.

The purpose of this work was to develop an energy-saving technology for the production of building materials (tiles, bricks, blocks, paving stones) using waste from PET and basalt, which is man-made waste from the corresponding mining and processing industries. Note that basalt is a volcanic rock, fine-grained, very hard, and composed mainly of feldspar and pyroxene or augite [9]. Basalt is common in Mexico and is widely used in construction.

2. Material and methods

The work used crushed household waste PET plastic measuring ~19 mm and basalt particles measuring 0.595 mm. Mixtures were prepared from PET and basalt, in which the PET component was changed from 90 to 30 wt.%, and the basalt component was changed from 10 to 70 wt.%. The mixtures, placed in metal molds of various sizes, were introduced into the oven at a temperature of ~ 260-280 ^{o}C. The holding time at this temperature was 2 hours. After cooling, the samples were removed from the molds.

The **compressive strength** of the samples was carried out according to the NMX-C-083-ONNCCE-2014 standard [10] and was calculated using the formula: σ = F/A, where σ is stress in the body, MPa (Kgf/cm^2); F = internal compression force, kgf; A is sample surface area, cm^2.

The **flexural strength** of the samples was carried out according to the ASTM C1161-02c standard [11] and was calculated using the formula: $M_r = \frac{3CL}{2ae^2}$, where Mr is the flexural modulus of elasticity, MPa; C is maximum breaking load, N; L is the length between lower supports, mm; a is sample width, mm; e is sample thickness, mm.

The magnitude of the **rutting deformation** of the paving stones was determined according to the standard M-MMP-4-05-053/21 "Residual deformation due to rutting with a loaded Hamburg wheel" [12] on a loaded Hamburg DWT wheeled vehicle with a wheel load of 705 N. The rutting deformation was determined by measuring the thickness of the deformation present in the samples at the end of the 20,000-pass cycle.

Water **absorption** of the samples was carried out in accordance with the standards NMX-C404-ONNCCE.2012 for bricks in walls [13] and NMX-C-314-ONNCCE-2014 for paving stones in road surfaces [14]. The amount of water absorption (W) is calculated by the formula: $W = (P_1 – P_o)/P_0 \cdot 100$, %, where: W is absorption value, %; P_o is weight of dry sample, g; P_1 is weight of sample saturated with water, g.

3. Results and discussions

The view of the obtained samples in the form of bricks is presented in **Fig. 1**. The results of **compression t**ests of the samples (**Fig. 2**) showed that σ is in the range of 12.87-18.1 MPa. Note that according to the standard for bricks and ceramic blocks from clay, the compressive strength is in the range of 8 to 12 MPa [15]. It can be concluded that based on the compressive strength, the composites/bricks obtained in this work are suitable for use in construction. For masonry with high load-bearing loads, and for foundations mixtures with a high PET content should be sintered (**Fig.2, I**). To construct durable buildings of 2-3 floors, you can use bricks/blocks obtained by sintering mixtures containing 70-50 wt./% PET (**Fig. 2, II**). When constructing one-story durable buildings, it is possible to use bricks/blocks obtained by sintering mixtures containing 40-30 wt./% PET (**Fig. 2, III**).

According to [15], **flexural** strength for bricks obtained from clay must be in the range 1.4-2.8 MPa, and for improved ceramics Mr ≥ 2.8 MPa [3]. So, it is possible to conclude that bricks obtained from mixtures with 70-50 wt.% PET can be used in the construction of external and internal walls in buildings with a maximum height of two floors (**Fig. 3, I**). Bricks made from mixtures with 40-30 wt.% PET, although they have high bending strength (**Fig. 3, II**), do not have good compressive strength (see **Fig. 2 III**).

From the totality of data on the strength of bricks/blocks in compression and bending, it can be concluded that from mixtures of (80-50) wt.% PET - (20-50) wt.% basalt, when sintered at 280 °C for 2 hours, it is possible to obtain good bricks quality for low-rise construction.

The results of **rutting tests** (**Fig. 4**) indicated that bricks/tiles produced from PET-basalt mixtures have higher resistance to deformation than the maximum allowed by the standard (10 mm) [12]. For the obtained samples, the deformation thickness is 1.6 mm. This means that their can be used as paving stones for sidewalks.

Water absorption for standard bricks obtained from clay consists of 6-8% [15]. For bricks obtained from mixtures of PET-basalt, (**Fig. 5**) water absorption is especially lower. This means they have good water resistance properties. Such bricks can be used (taking into account their strength properties) for laying a foundation, as roof tiles, for the construction of swimming pools, tanks, storm sewer hatches, septic tanks, channels, curbs, and gutters.

4. Conclusions

Studies have shown that after temperature treatment at 260-280 °C of PET-crushed basalt mixtures, it is possible to obtain building materials (bricks, blocks, tiles, tiles) that are not inferior in strength properties to traditional brick products made from clay. By changing the content of components, it is possible to obtain composites with different strengths for compression and fracture. So, bricks made from mixtures of (90-80) wt.% PET - (10-20) wt.% basalt has a compressive strength (σ) ~ 18.1-17.52 MPa and can be used in masonry with high load-bearing loads. Building materials obtained from mixtures of (70-50) wt.% PET - (30-50) wt.% basalt have σ ~ 16.26-14.74 MPa and can be used in the construction of a building with a maximum of two levels. Brick products made from mixtures of composition (40-30) wt.% PET - (60-70) wt.% basalt have σ ~ 13.62-12.87 MPa and can be used in the construction of one-story buildings. Building materials made from mixtures of (40-30) wt.% PET - (60-70) wt.% basalt are highly resistant to deformation (1.11-1.66 mm) and can be used as paving stones. Due to the fact that samples from mixtures of (90-30) wt.% PET - (10-70) wt.% basalt have a low water absorption value (W~0.26-1.41)%, they can be used in the construction of swimming pools, tanks, storm sewer hatches, septic tanks, channels, curbs, and gutters.

Taking into account the energy, water intensity, and complexity of the traditional technology for the production of brick products from clay compared to the energy-, water-saving, and easy-to-implement technology for the production of durable building bricks from waste PET --basalt, one can foresee the widespread application of this technology in the building industry.

Figures captions

Fig. 1. View of samples obtained from various PET-basalt mixtures with dimensions of 200 x 100 x 60 mm.

Fig. 2. Compressive strength of samples depending on the composition of the initial PET-basalt mixtures. (I) bricks for high load-bearing loads; (II) bricks for buildings of 2-3 floors; (III) bricks for buildings of 1 floor.

Fig. 3. Flexural strength of samples depending on the composition of the initial PET-basalt mixtures. (I) bricks for buildings of 1- 2 floors; (II) bricks for buildings of 1 floor.

Fig. 4. The value of rutting deformation of samples/paving stones obtained from mixtures of 40 wt.% PET - 60 wt.% basalt (1), and 30 wt.% PET - 70 wt.% basalt (2).

Fig. 5. The value of water absorption of samples depending on the composition of the initial mixtures of PET-basalt.

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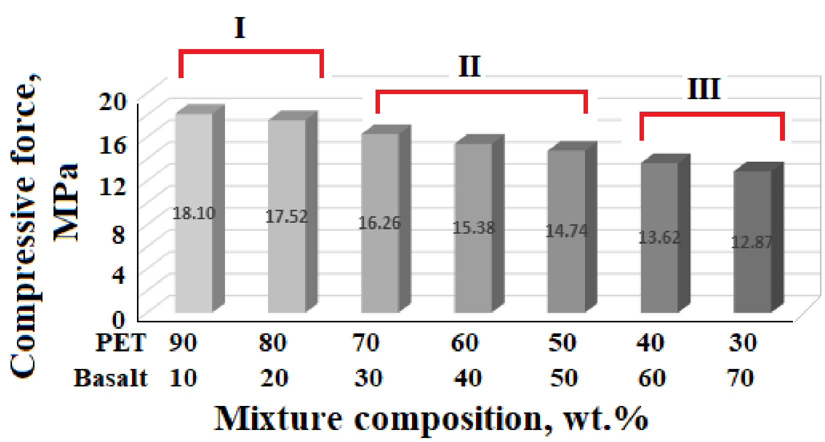
Fig. 1. View of samples obtained from various PET-basalt mixtures with dimensions of 200 x 100 x 60 mm.



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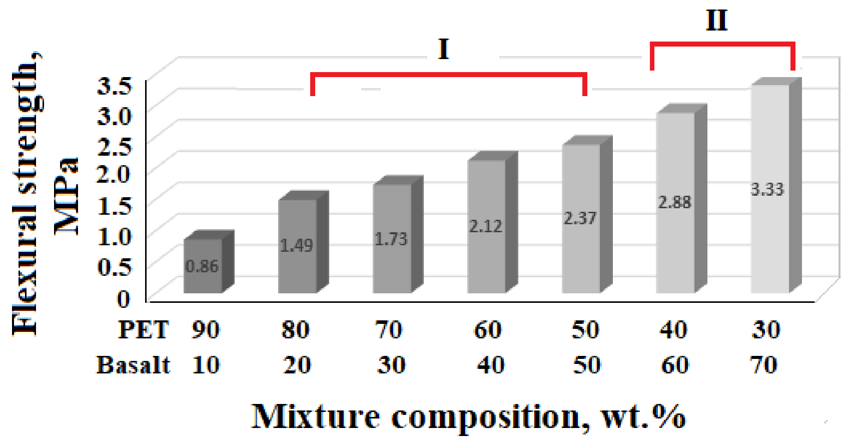

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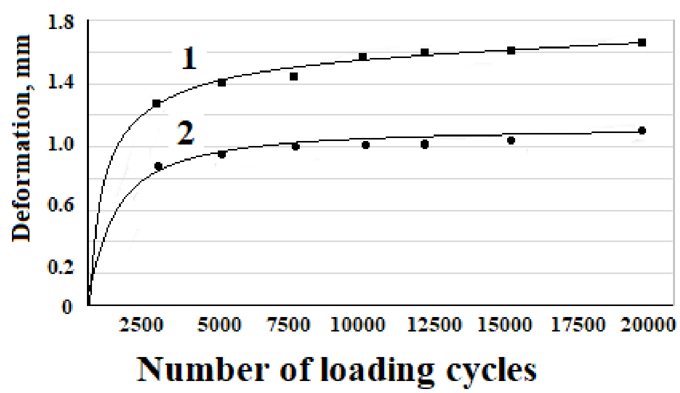

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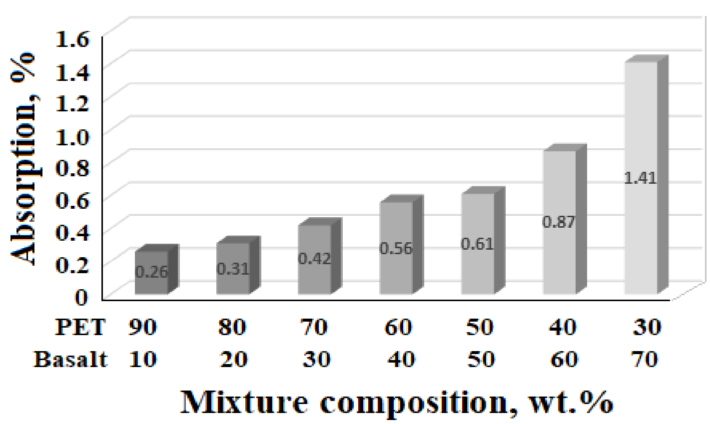

Fig. 5. The value of water absorption of samples depending on the composition of the initial mixtures of PET-basalt.

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