POLYMER WASTE MANAGEMANT – ENVIRONMENTAL SAFETY STRATEGY

Ass. Prof. PhD in Tehn. Sc. Malyshevska O.[1], Prof. Dr. of Medical Sc. Garkavij S. [2], Ass. Prof. PhD in Mineralogical Sc. Melnyk O.[3], Prof. Dr. of Medical Sc. Mizyuk I.[4], Ass. Prof. PhD in Biology Myshchenko I. [5]
[1,4,5] Ivano-Frankivsk National Medical University, Ivano-Frankivsk, Ukraine, e-mail1: o16r02@gmail.com, e-mail4: michaylo.m@gmail.com, e-mail5: kolg.ira21@gmail.com,
[2] Bogomolets National Medical University, Kyiv, Ukraine.; e-mail: garsi@i.ua
[3] Ivano-Frankivsky National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine, e-mail: odmelnyk@ukr.net

Absract: *wasteless technology for processing of plastic waste and food packaging polymer, which is based on the usage of mechanical recycling as the most environmentally friendly way of plastic waste recycling has been developed. The introduction of various kinds of plastic waste, including plastic packaging waste, into sand cement compositions, allows, on the one hand, to dispose millions of tons of plastic waste and at the same time to reduce the negative impact of the last ones on the environment and humans. On the other hand, it allows substituting expensive fibreboard fibres by substantially cheaper polymeric waste, preserving and improving the properties of concrete mixtures, to which they were administered. The resulting product can be used as filler in a cement-sand mixture, which can significantly improve the physicomechanical, thermal and rheological properties of the product made on the cement-sand based mixtures.*

KEYWORDS: ENVIRONMENTAL SAFETY, HYGIENE, WASTE POLYMERS, POLYMER PROCESSING, RECYCLING PACKAGING AND RECYCLING.

1. Introduction. Increasing of production and usage of polymers continually raise their wastes amount. The latest research of the world market of plastic package consumption, carried by company Smithers Pira shows that its world production was 16,7 million in 2015 with the annual gain in 3,8%. As a result, the consumption of plastic will increase by 4,8% up to 15,5 million tons in 2016. During the next 5 years, the consumption is believed to be 21,1 million tons in 2021, with annual increasing by 3,8%. Despite economic factors, increasing in plastic package consumption remains stable [1]. We predict more intensive increasing of consumption in 2016 mostly due to increasing of bottled water usage rate and decreasing of PET resins price as well. This process is provided by regions where glass and metal package for milk, juice, beer and wine continuously replaced by plastic one.

Creating of waste less ecological-friendly technology based on mechanic recycling of polymeric waste and material containing polymeric waste is one of the most actual and safe ways of waste processing.

2. Preconditions and means for resolving the problem.

It's known that synthetic fibers have low wettability and consequently bad adhesion with cement stone (fig. 1).

Adhesion of filling agent and cement stone has a determinative influence on physical-mechanical properties of concrete. Adhesion is caused by close attachment and joining of cement stone with the filling agent which is achieved due to a rough surface of the filling agent. The best attachment and joining have the filling agents whose surface lets the concrete get into a filling agent.

Figure 1. Lack of adhesion of cement stone with polyamide fibers. Electron micrograph [2].

It is known that polymer wastes have low ability to adhesion and absorption due to smooth, almost polish surface. During adding of any kind of filling agent into cement matrix, the most important moment is "gluing" of hydrophilic (organic) and hydrophobic (clinker mineral) surfaces. Well-studied polymeric fibers that are widely used in a building have a low degree of adhesion with the concrete stone which is caused by low adhesion and sorption. Moreover, they are chemically inert substances in relation to the components of the concrete mixture. Today scientific proposals in this field are limited by changing of polymeric fibers shapes.

The fibers are made in shapes of ropes, spirals, and waves that have different hooks on their surface and so on [3, 4].

In response to the problem of adhesion between polymers and cement matrix, it's necessary to create conditions of growing of cement matrix crystals on the surface of the polymeric filling agent.

Towards the solution of this problem, we suggest milled polymeric wastes were mechanically activated in a specially made device [5].

Conducted experimental research proved correctness and efficiency of that choice.

Solution of the examined problem. In order to solve the set problem, we conduct several experimental pieces of research for obtaining concrete mixtures filled with polymeric wastes which will meet requirements of Union State Standards specifically adhesion with cement stone, compressive strength and flexural strength, durability, convenience laying, hardening rate.

Researches were carried out with the usage of polymeric wastes. During experiments, the following parameters were changed: proportions of filling agents in the mixtures, type of polymeric filling agent (mechanically activated. Our aim was to achieve an optimal composition of cement mixtures and appropriate limits of polymeric wastes addition without deterioration of concrete physical and chemical properties. For obtaining of polymeric filled cement mixture it's necessary to mix previously milled and mechanically activated polymeric wastes with adding of cement, sand and water.

The composition of experimental samples: cement-sand-water (3:1:0.4), the polymeric filling agent from 1-15% from a total sand mass.

Experimental investigation of procedure. Milled polymeric wastes were mechanically activated in a specially made device [5]. Then processed wastes were added to sand and cement mix. The dry mixture was blended in the mixer for 2.5-3 min after that water was added. After addition of water to the mixture, cement grout was mixed for 3 minutes, left for 5 min and mixed again for 2 min. Repeated mixing is used for prevention of premature concrete setting. The mixture was laid in layers and compacted by a metal rod in molds with size 160x40x40 mm. After the laying, samples were vibrated during 1 min, then were left for 15 min and were vibrated again for 2 min.

By the variety of researchers, it has been established that colloid structure which is formed at the end of the first stage can be easily changed in a certain required way. Repeated vibration conducted at the end of the stage when electroconductivity of concrete mix is maximal allows to increase concrete strength and to reduce its permeability.

In this way, 6 samples of each kind of concrete mix were made. Then these samples were left in molds during 24 hours (± 1 hour). After they were placed in a container with water during two days. In 72 hours (± 2 hours) from the moment of preparation, according to methodologies BS EN 12390-3:2009, BS EN 12390-5:2009 [6, 7] compressive strength and flexural strength tests were conducted. The same researches were carried out after 28 days when the concrete stone has maximum strength with the other half of the samples. During the experiments, the method of mathematical planning was used. Analysis of the experimental data was carried out using a statistical analysis package "STATGRAPHICS" by multifactor model's construction.

Results and discussion. Obtained results of compressive strength and flexural strength tests of concrete samples show their dependence on the amount of filling agents (polymer wastes) and in the concrete mixture.

Figure 2 presents results of compressive strength test. As it can be seen, control sample had on concrete strength of compressive 10.27 and 26.6 H/mm2 on the 3nd and 28th days accordingly. The presence of polymer wastes in the concrete samples changed this index. The best results were obtained for samples containing 7% of polymer wastes. After three days, these samples compressive strength 11.34 H/mm2, on the 28th day this index increased up to 29.87 H/mm2 which exceeded results of control sample on 10,4 % (3nd day) and 12.3 % (28th day).

Results of flexural strength test are shown in Figure 3. Comparing with the control sample, the best strength had those ones containing 7 % of PET wastes. As it could be seen from the Figure 3, after three days of setting, flexural strength of samples with 7 % of polymer wastes was improved on 21.65 % of samples with polymer wastes in comparison with the control sample.

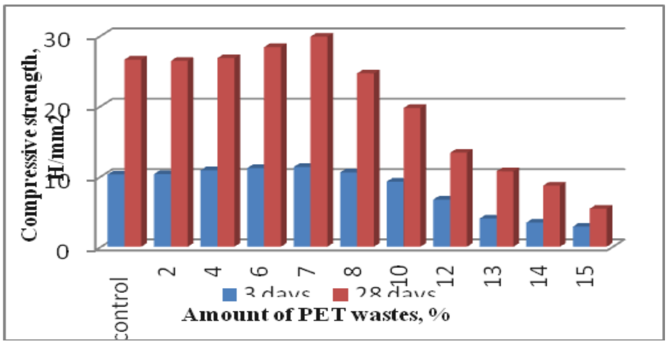

Figure 2. Results of compressive strength test for control sample and those filled with polymer wastes after 3 days and 28 days

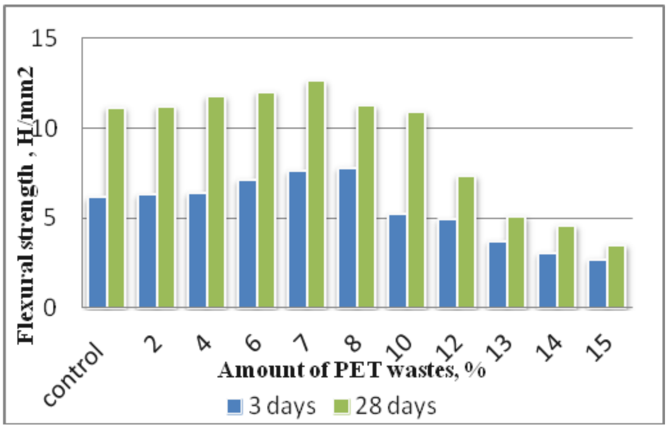

Figure 3. Results of flexural strength test for control sample and those filled with polymer wastes after 3 days and 28 days

After 28 days obtained results were not so significant but the main trend was the same. Maximal flexural strength was observed for samples with 7% of PET wastes. Improvements were 5.35 %.

All samples with polymer wastes can be characterized by:

- the absence of cracks formation at visual observation;
- decreasing of concrete shrinkage;
- reducing of concrete weight up to 21.3% without loss of its strength properties;
- increasing of cohesion of polymer wastes with the concrete stone which was confirmed by mechanical researches;
- improvement of concrete compressive strength and flexural strength, especially at the initial stages of concrete formation due to reinforcing and more even distribution of cement particles in samples.

Conclusions and prospects of further researches.

Experimental researches proved that mechanical activation of polymer wastes leads to improvement of cohesion of polymer wastes in concrete. Increasing in the amount of polymer wastes up to 10% doesn't have a negative impact on physical properties of the concrete stone.

New concrete mixtures filled with polymer wastes have been prepared. Obtained mixtures have improved physical and mechanical characteristics and better adhesion of polymer wastes with cement matrix.

It allows to:

- reduce amount of polymeric wastes;
- put into practice basic international principles in ecological policy creating the non-waste technology of polymeric wastes recycling;
- obtain goods with better physical properties;
- use polymer wastes instead of expensive raw materials;
- achieve an essential saving of raw materials, energy and money resources;

Obtained results are underlying and will be used for further researches for determination of limit doses of polymeric wastes which can be added to concrete mixtures.

Present research proceeds innovative approach in the utilization of polymeric wastes by adding into their composition concrete mixtures.

Reference.

1. http://www.smitherspira.com/industry-market-reports/packaging/the-future-of-pouch-packaging-to-2021

2. www.trotuar.ru/forms/dobavki/fibra2.shtml

3. Merkley J. D., Caidian Luo. Fiber cement composite materials using bleached cellulose fibers (2012). Patent number 8333836. Publication number 20110248421. Application number US

13/066,163.
4. Tanaka Yoshihiro, Hashimoto Osamu, Nishi Kazuhiko. Fiber reinforced cement based mixed material (2015). Patent number PCT/JP2012/079468. Publication number US9145337 B2. Application number US 14/359,071.
5. Malyshevska O., Melnyk A (2015). Patent № 110282. The method of recycling PET bottles.
6. BS EN 12390-3:2009. Testing hardened concrete. Compressive strength of test specimens. (British standard 12390-3; 2009) Unknown Binding. – 15 May 15, 2009.
7. BS EN 12390-5:2009. Testing hardened concrete. Flexural strength of test specimens. (British standard 12390-5; 2009) Unknown Binding. – 15 May 15, 2009.