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# The use of environmentally acceptable plastic materials based on cement and polymer composites with out of consideration to their physical properties

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**Abstract.** The aim of the research is to find possibilities for the re-use of environmentally eligible plastic waste as one of the options as a filler in light concretes. The plastic waste was obtained by recycling the plastics from the packaging of electrical cables, Ethylene-vinyl acetate and waste from expanded polypropylene in various proportions. All plastics are included among the medium-sized recyclable plastics according to the degree of their recycling. The experimental part of this work is devoted to verify the impact of the dose of fillers on the observed physical properties (bulk density, heat-technical parameters, sound absorption) of light concrete.

## 1. Introductions

Currently, the recycling in Slovakia is only about 1.2 % of municipal waste [1]. Great attention is paid to waste on the use of recycled plastic [2-5], for example, Recycled polystyrene, polyurethane foam, PET bottles, waste from electrical and electronic devices, PVC pipes etc. One of the ways to use recycled materials of plastics is to include them in light concrete, the selection of the appropriate combination of filler and binder will form building material not only for the next construction, but also for remodeling, rehabilitation, new materials etc.

Plastics, with their weight, form less than 8% of the waste, but the volume is much bigger, this is particularly important in landfills, where volume is more important than weight. Plastics are mostly non-reproducible oil, whose stocks are estimated at 40 years. Only by their transportation, 3.5 million tons is annually released into the surface-water. The biological decomposition of plastics in the nature or in landfills is long-term, it takes several decades. In case of combustion of certain kinds of plastics, harmful substances escape into the air. SR recycles 16% of the plastics [1].

Plastics are used as some of the most common packaging, and thus are among the most common type of waste that is produced nowadays. Plastics were supposed to be a replacement for natural materials, natural resin, or glass fiber. Now they are considered to be a special group of materials with unique properties. Today, they are used as high-molecular-weight organic compounds. Initially these were mainly natural materials, such as cellulose, proteins, rubber, and resin. Plastics are produced by the process of the so-called polymerization, in the small short molecules together in a long variety of linked chains. Therefore, there are several hundred different polymers with very different properties [6].



## 2. Materials and methods

For experimental testing for the research of the recycled waste such as polypropylene (L1) ethylene vinyl acetate (EVA) (L3), and recycled material from cables (L5) was used as shown in figure1. Materials and components of mixtures were mixed in following proportions: fillers 100 % PP (L1) binder Conipur 360, fillers 50 % PP + 50% EVA (L2) binder Conipur 360, fillers 100% EVA (L3), binder Conipur 360, fillers 50% EVA + 50% PVC (L4), binder Conipur 360 and fillers 100 % PVC (L5) binder Conipur 360.



**Figure 1.** Plastic waste fractions:

Polypropylene is very light and strong graining. Polypropylene is a thermoplastic polymer from the group of polyolefin used in many sectors of the economy. Polypropylene features with very good chemical and mechanical resistance. For research were used the waste from the recycled polypropylene (L1). Ethylene-vinyl acetate (L3) is the elastomeric polymer with high elasticity, known as the ethylene-vinyl acetate (EVA) [7]. The recycled material of the cables is a pulp recycled cable PVC where the cable core is formed, in particular polyvinyl chloride (L5) [8].

The polypropylene and EVA were crushed and the fraction 4/8 mm screened cable for the fraction 0/4 mm, wherein the bulk density of polypropylene  $17.52 \text{ kg.m}^{-3}$ , EVA  $104.41 \text{ kg.m}^{-3}$  and cable  $359.33 \text{ kg.m}^{-3}$ . LB were produced with the use of a filler, or as a combination of two materials according to the percentage share: 100%, 50:50 % (table 1).

As binder was used undiluted one-component polyurethane adhesive Conipur 360. This adhesive is used in the implementation of the polyurethane surfaces. It has a firming effect, it is resistant to abrasion and very easily workable. Dose of glue in all mixtures was also a constant of 0.8 l per one mixture. Considering different surface and material was - moistened 2% water content, which regulates the surface tension.

**Table 1.** Composition of the individual mixtures.

Test samples	Binder (l) Conipur 360	PP	Graining (l) EVA	Cable
<b>L1</b>	0,8	8	0	0
<b>L2</b>	0,8	4	4	0
<b>L3</b>	0,8	0	8	0
<b>L4</b>	0,8	0	4	4
<b>L5</b>	0,8	0	0	8

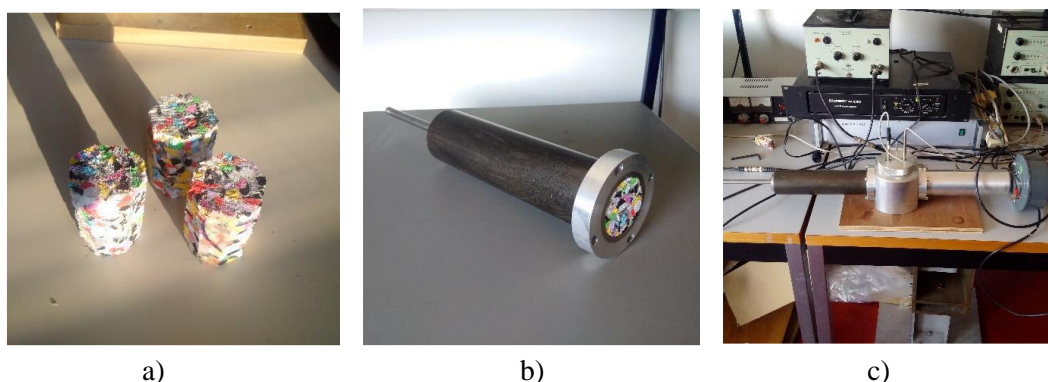
Samples in the shape of  $100 \times 10 \times 100 \text{ mm}$  were made from homogeneous mixtures. These samples were treated 48 hours in the laboratory environment. Subsequently, they were removed from the mold and stored in laboratory environment ( $20^\circ \text{C}$ , humidity= 50%). Subsequently, the physical properties (bulk density, heat –technical parameter and thermal conductivity) were measured. The sound

absorption was tested only on the EVA sample. Measurements of bulk density and heat of technical parameters were carried out in the laboratory conditions of the STU.

### Sound absorption

Measurements of sound absorption were performed by the acoustic laboratory at KU Leuven (The Katholieke Universiteit Leuven, Belgium). Due to the complicated measurement and sample size (according to STN EN ISO 354 [9], the sample's size is  $10\text{m}^2$ ) the sound absorption was verified only on small EVA samples (L3) in the impedance tube. These measurements were made only in KU Leuven. For this purpose, the impedance tube was measured on samples L3 (figure 2). Knowledge of the sound absorption of building materials, opens up the possibility of their applications also in terms of dampening the sound as in the interior (generally in diffusion audio field), as well as in the outdoors (free sound field) [10-11]. The experiment was focused on the measurement of the sound absorption factor. For this purpose, a set of L3 (EVA) samples for measurement in the impedance tube was modified. For the verification of sound absorption was used ethyl-vinyl acetate (EVA), in combination with the binder Conipur 360 (polyurethane glue). It was a sample with thickness of 6.5 cm. Diameter of cylinder of the sample was 4 cm. The measurement and the used measuring assembly operates on the principle described in the standard ISO 10534-2 [12-13].

Subsequently, the first results were measured in the acoustics laboratory. Figure 2 shows the measurement of sample L3.



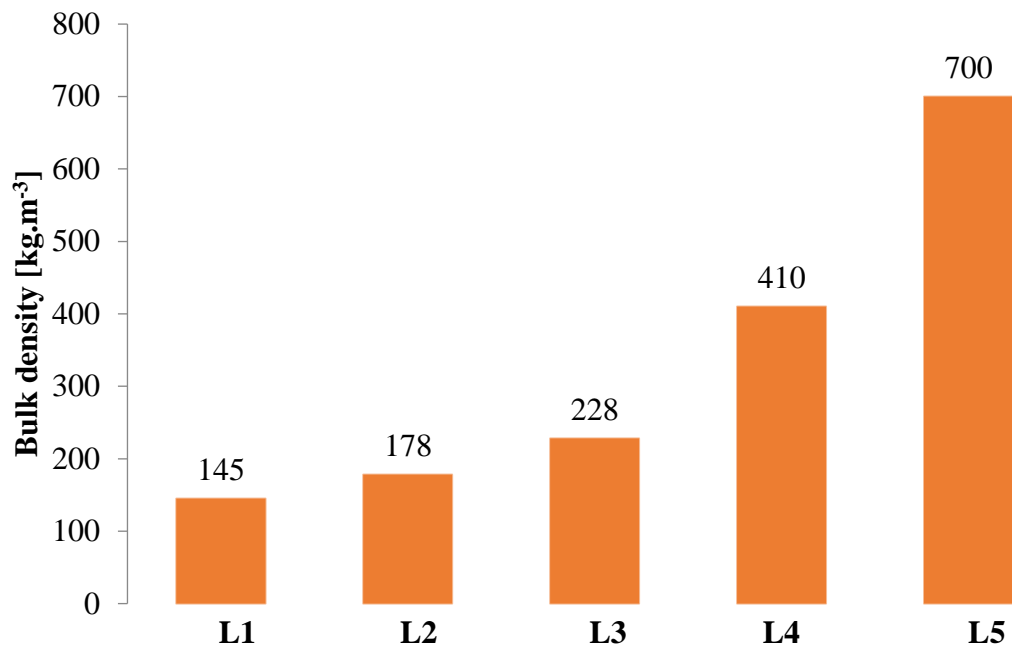
**Figure 2.** The measurement of the sample EVA (L3):  
a) L3 b) The sample is inserted into the piston metering assembly c) impedance tube.

### 3. Results

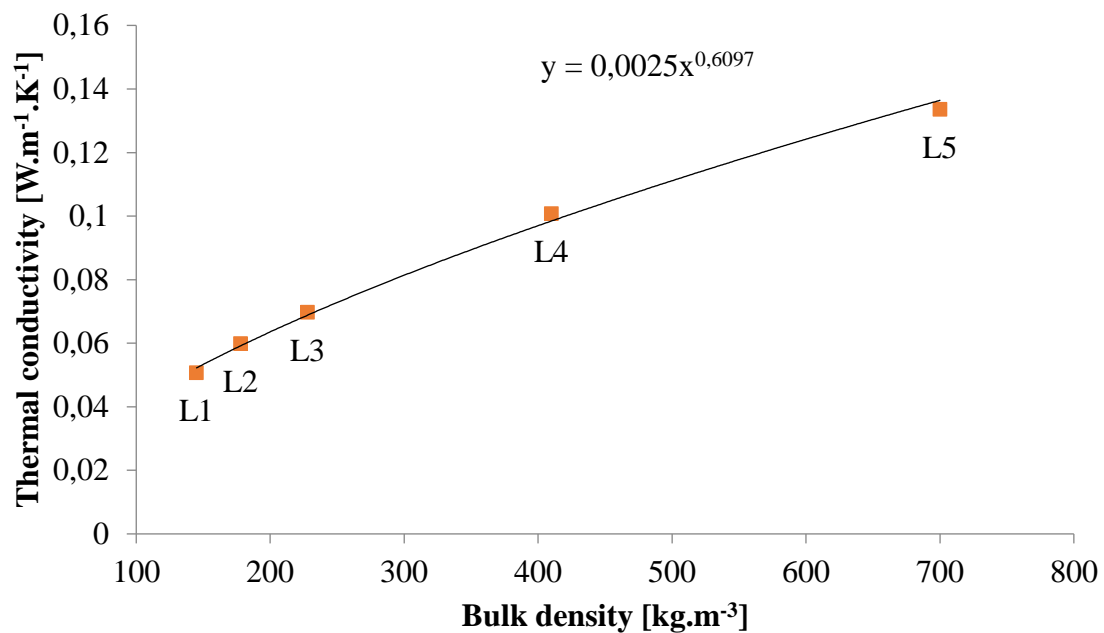
Physical and thermophysical properties are shown in (figure 3,4).

While the bulk density of samples from PP (L5) and EVA (L3) ranged from  $245$  to  $230\text{ kg.m}^{-3}$ , the cable (PVC) increased by an increasing proportion of PVC due to a higher bulk of the input material reaching values up to  $700\text{ kg.m}^{-3}$  (figure 3).

With the increasing proportion of PP (L1, L2), the thermal conductivity coefficient of the test samples decreased, and vice versa with increasing proportion of cable fillers, the coefficient of thermal conductivity of the test samples increased (L4, L5) (figure 4).



**Figure 3.** Comparison of the Bulk density of mixtures.

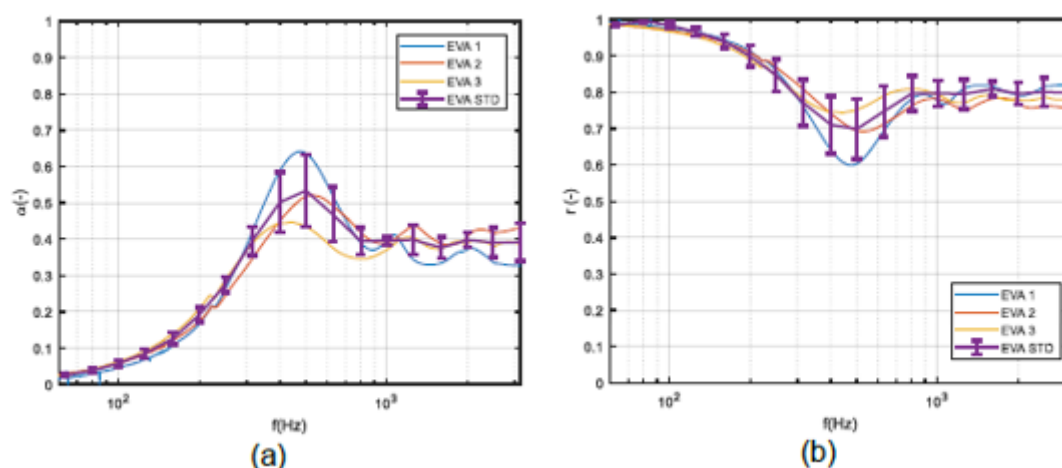


**Figure 4.** Relationship between thermal conductivity and bulk density of mixtures.

Figure 5 shows the results of the factor of sound absorption  $\alpha$  (-) and factor of reflection of the acoustic pressure in the perpendicular impact of the sound of the  $r$  (-) measured in an acoustic laboratory at the KU Leuven (Belgium). Results obtained by this measurement (verified impedance tube with high precision, stability and all repeatability of this measurement) are in this work taken as basics. From results is clear, that already in the comparison of three samples, of the same composite, there have been deviations in the measured values up to 10%. It may predestinate the diversity of the

measured sample, but also the way of installing the sample into the measuring report (samples were bigger than the diameter of the measuring piston, and so were manually modified).

The results of the KU Leuven gave lower values of absorption than assumed. The transformation (gear) method offers greater stability. Its advantage is also the duration of the measurement when the measurement is made within 10 minutes. Measured values are relevant for the frequency range 1250 - 1500Hz.



**Figure 5.** The resulting spectrum for the perpendicular impact of the sound waves with their standard deviation (L3):

a) Range of agent sound absorption; b) The absolute value of the factor of reflection.

#### 4. Conclusion

On the basis of the results we can say that samples of plastic materials (L1, L2, L3) have favorable thermal properties with the binder. It can be stated that the use of recycled PP, EVA and PVC has a perspective in the production of lightweight concrete. Use of these materials can be envisaged in the construction industry. Standardized methods (Transformation Transition Method) have been considered in the Experiment of Determining Sound Absorption Factor (L3). The method does not require large samples and the assembly of the measurement set for basic sound absorption verification is financially less demanding. In summary, recycled plastic waste has a future in construction as well as in combination with various other plastic waste using a suitable binder. In view of their reuse in practice (eg with floor insulation), it would be advisable to further monitor and verify acoustic parameters.

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