MDA2020

3RD INTERNATIONAL CONFERENCE ON MATERIALS DESIGN AND APPLICATIONS

5-6 NOVEMBER 2020

FACULTY OF ENGINEERING - UNIVERSITY OF PORTO

PORTO - PORTUGAL

NOVEL LIGHTWEIGHT CONCRETE MADE FROM FOOTWEAR INDUSTRY WASTE

M.C. Baptista[1], M.L. Garcia[2,3], S.C. Pinho[1,4], M.A. Lopes[1,5], M.F. Almeida[1,4], C. Coelho[6] and C. Fonseca[1,7]

[1]FEUP, Department of Metallurgical and Materials Engineering, UP, Portugal
[2]ISEP, Department of Civil Engineering, IPP, Portugal
[3]NBIN/CIETI - Center for Innovation in Engineering and Industrial Technology, IPP, Portugal
[4]LEPABE - Laboratory for Process Engineering Environment, Biotechnology and Energy, UP, Portugal
[5]LAQV/REQUIMTE – Associated Laboratory for Green Chemistry of the Network of Chemistry and Technology, UP, Portugal
[6]ATLANTA – Componentes para o Calçado, Lda., Lixa, Felgueiras, Portugal
[7]LAETA/INEGI – Institute of Science and Innovation in Mechanical and Industrial Engineering, UP, Portugal

OBJECTIVES

- **Development of a new Lightweight Concrete (LC) using an Ethyl-Vinyl Acetate (EVA) waste from the footwear industry;**
- **Evaluation of the influence of the EVA content (replacing natural aggregates) and its particle size on concrete density, workability and compressive strength.**

CONTEXT OF THE WORK

The footwear industry plays an essential role in the Portuguese economy since it mobilizes almost 1500 companies, and it generates approximately 40000 jobs. To keep competitive, the cluster should keep investing in creativity and mastering of the entire production process, including the product life cycle, in order to add value in each phase.

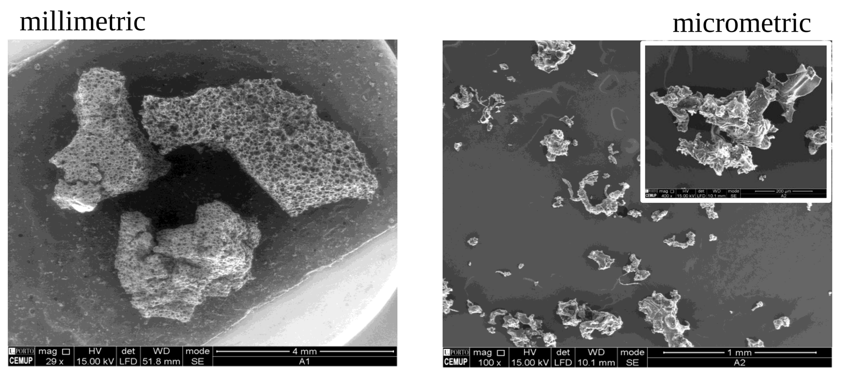
Ethylene-vinyl acetate (EVA) is one of the most used polymers in the footwear industry, due to its low price, suitable mechanical properties and its ability to be processed in different forms (e.g., foam). However, since it is a non-biodegradable plastic, EVA wastes generate a critical environmental concern that demands sustainable solutions.

MATERIALS AND METHODS

- Cement (Secil, Portland cement, CEM I, 42.5 R, Macieira-Liz);
- Water (Porto public water supply network);
- Natural aggregates: fine sand (0/2), medium sand (0/4) and LECA® S;
- EVA polymer foam (waste).

EVA shredded and sieved

mm EVA — millimetric | µm EVA — micrometric



(1 – 3.15) mm | < 562 µm

Control Lightweight Concrete VS **EVA incorporated in Lightweight Concrete**

Control: Mass trace (cement : fine sand : medium sand : LECA® S : water) with 1% FM735
1 : 2.75 : 0.82 : 0.44 : 0.53

EVA: Replaces 25% and 50% (v/v) of fine sand (0/2)

NP EN 12350-1:2009

RESULTS AND DISCUSSION

Table 1: Properties of the raw materials used in Lightweight Concrete.

Components	Cement	Fine sand (0/2)	Medium sand (0/4)	LECA® S	mm EVA	µm EVA
Specific gravity	3.10	2.62	2.62	0.65	0.64*	1.12*
Bulk density [kg.m^{-3}]	1150.0	1602.2	1735.6	430.0	241.1	268.0

*determined by helium pycnometry.

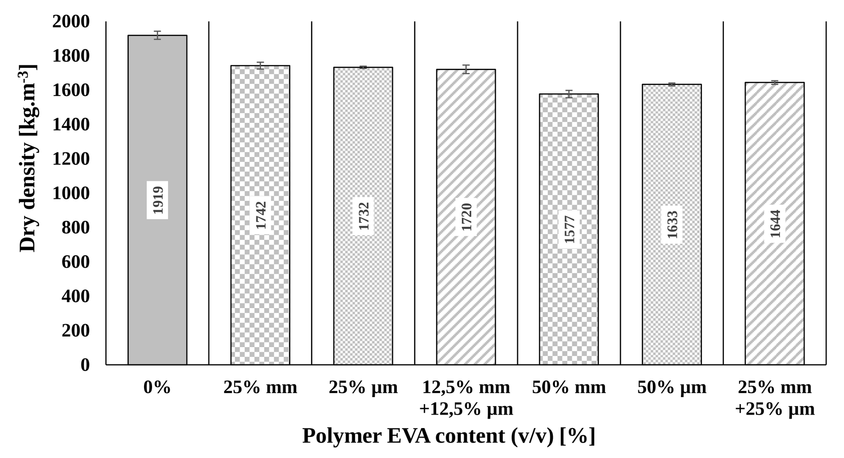


Fig. 1: Dry density of the LC as a function of EVA content and granulometry (mm and µm).

NP EN 12390-7:2009

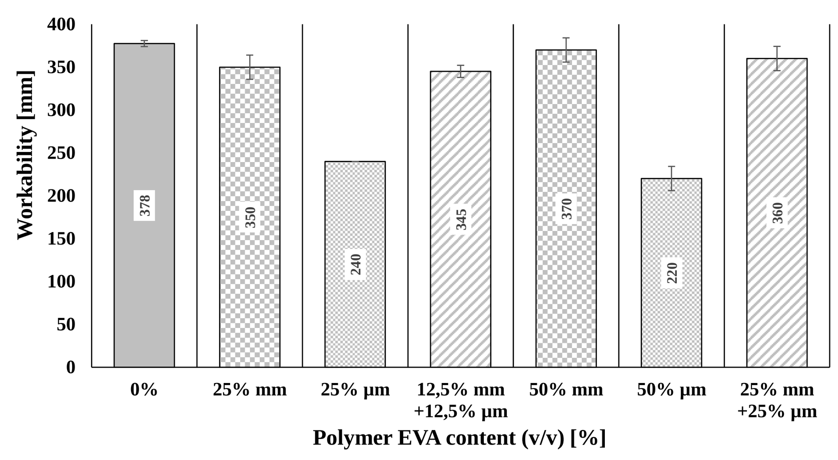


Fig. 2: Workability of the LC as a function of EVA content and granulometry (mm and µm).

NP EN 12350-5:2009

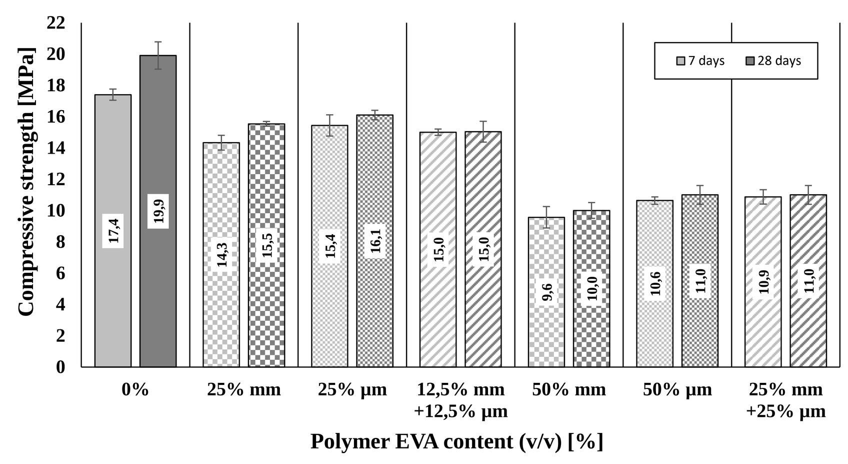


Fig. 3: Compressive strength of the LC as a function of EVA content and granulometry (mm and µm).

NP EN 12390-3:2011

- Increase of EVA content leads to a decrease of dry density of the LC of 18% for mm EVA and 15% for µm EVA (50% EVA replacement);
- Presence of EVA, mainly micrometric, causes a decrease of workability: 2% and 42% for mm EVA and µm EVA, respectively (50% EVA replacement);
- Compressive strength decreases with increasing EVA content, being attenuated with micrometric EVA: 50% and 45% for mm and µm EVA, respectively (50% EVA replacement at 28 days).

CONCLUSIONS

- **The presence of EVA waste in concrete translates in a lighter concrete, with lower workability and inferior compression strength;**
- **Experiments with ½ mm EVA + ½ µm EVA proved to be a good strategy when working with the incorporation of polymeric waste, since it allows to achieve a good balance between concrete properties and polymer processing costs.**

REFERENCES

[1] Babafemi, A., Šavija, B., Paul, S., and Anggraini, V., Sustainability, "Engineering Properties of Concrete with Waste Recycled Plastic: A Review", 10 (11), 3875 (2018).
[2] Gu, L. and Ozbakkaloglu, T., "Use of recycled plastics in concrete: A critical review" Waste Management, 51, 19-42 (2016).
[3] Sharma, R. and Bansal, P. P., "Use of different forms of waste plastic in concrete - A review", Journal of Cleaner Production, 112, 473-482 (2016).

The authors acknowledge financial support from the project FAMEST, ref. POCI-01-0247-FEDER-024529, co-financed by COMPETE2020 through PT2020 and FEDER. They also grateful to Atlanta, Componentes Para Calçado, Lda. for the supply of EVA polymer.