

# Lightweight Materials for Building Finishing

Sarka Keprdova, Nikol Zizkova

**Abstract**—This paper focuses on the presentation of results which were obtained as a part of the project FR-TI 3/742: “System of Lightweight Materials for Finishing of Buildings with Waste Raw Materials”. Attention was paid to the light weighting of polymer-modified mortars applicable as adhesives, screeds and repair mortars. In terms of repair mortars, they were ones intended for the sanitation of aerated concrete.

**Keywords**—Additives, light aggregates, lightweight materials, lightweight mortars, polymer-modified mortars.

## I. INTRODUCTION

SINCE July 2011 to December 2014, the Institute of Technology of Building Materials and Components, Faculty of Civil Engineering, Brno University of Technology has been implementing the project of the Ministry of Industry and Trade of the Czech Republic FR-TI 3/742: “System of Lightweight Materials for Finishing of Buildings with Waste Raw Materials”.

The goal of the project is to create a set of lightweight building materials, components and product sets to be applied in the building industry, making use of lightweight fillers, lightweight fillers made from waste raw materials or directly utilising waste raw materials. These products will subsequently be introduced into the product range of the company Stomix, spol. s r.o., Skorošice.

Building materials, components and their sets are intended for application in building for which reason this project develops entirely new ones or innovates a material, component or system from the existing portfolio of Stomix, spol. s r.o., Skorošice. The individual materials, components or systems must reach top-level technological and economical parameters. Their intended field of application is in new constructions as well as the sanitation of existing degraded structures. They also serve a protective and aesthetic purpose. The light weighting of these materials contributes, among others, to attaining beneficial thermal-technical parameters with minimal extra load on the base building structure.

The project “System of Lightweight Materials for Finishing of Buildings with Waste Raw Materials” deals with the development of new lightweight building materials for building finishing which represent a system of the whole spectrum of materials ranging from lightweight plasters and screeds to various lightweight decorative mixtures.

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## A. Polymer-Modified Mortars

Polymer-modified mortars (PMM), using recently developed high grade redispersible polymer powders and aqueous polymer dispersion, have become popular construction materials in the world, particularly for finishing and repair works [1]. PMM are represented by fairly complex systems [2]. Commercially available polymer-modified mortars produced as a dry product consist of a binder, mineral fillers and are usually modified with redispersible polymer powder and working agents. The most typical binder is ordinary Portland cement used in combination with different types of mineral fillers [3]. Among several varieties of polymers available on the market, ethylene vinyl acetate (EVA) copolymer has been the standard choice for the polymer in dry set mortar because it can be widely found as a redispersible powder (RP) and it has excellent compatibility with cement-based systems [4]. EVA copolymer is added to mortars and concretes during mixing to improve properties such as elastic modulus, fracture toughness, impermeability, and bond strength to various substrates as well as retention capacity and plasticity in the fresh state [5], [6]. Redispersible powders are spray-dried dispersions [7]. Cellulose ethers (CE) are widespread admixtures introduced into industrial mortar formulations to fulfil specific tasks during the handling stage. As a popular thickening and air entertainment agent, CE allows to adjust the workability of the fresh cementitious material at a desired level by controlling the water balance [8]. CEs such as hydroxy ethyl methyl cellulose (HEMC) and hydroxy propyl methyl cellulose (HPCM) are common admixtures [9].

## B. Aim of the Research

The objective of this research was to use an alternative raw material source, preferably a by-product, which would contribute to the decrease of bulk density.

The newly developed light repair mortars useable with aerated concrete must meet following requirements: bulk density 400–480 kg/m<sup>3</sup>, compressive strength max. 2.5 N.mm<sup>-2</sup> and adhesive strength on substrates 0.3–0.5 N.mm<sup>-2</sup>.

## II. MATERIALS

### A. Reference of Polymer-Modified Cementitious Mixture

The reference PMM consists of a binder, fillers, and polymeric admixtures that must be applied considering the required final properties. Portland cement CEM I 42.5 R and fly ash were used as a binder, ground limestone (40VA, 0.0 – 4.0 mm) and sand were used as filler, and additives (EVA copolymer, cellulose ether, super plasticizer and defoamer). For the purposes of this paper, the reference mixture is identified as “REF”.

### B. Specification of Materials Used for Density Reduction

As the substitutes of the filler, representatives of light materials were selected (perlite, Liapor, foam polystyrene, vermiculite, rubber granulate, HD-PE micro granulate, Poraver, foamed glass Refaglass and Liaver), which have already successfully established themselves in production in a number of construction materials. It would be possible to say that these are the most commonly used light fillers, of whom we know their important properties, and are commonly available on the market for construction materials.

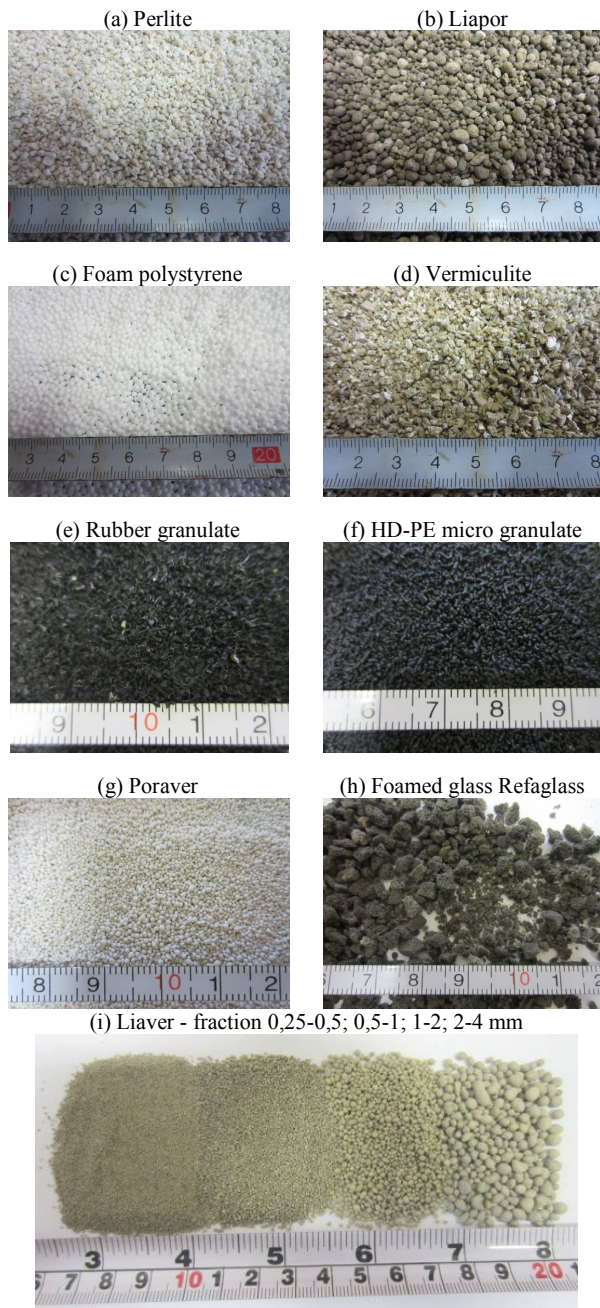


Fig. 1 The illustration of the light fillers

TABLE I  
THE FORMULA FOR THE REFERENCE MIXTURE

The individual component	% weight
Sand PR 32	16
Ground limestone (0.0 – 4.0 mm)	41,03
Cement CEM I 42,5 R	36
Fly ash	4,8
Aditives	2,17

### III. WORK METHODOLOGY

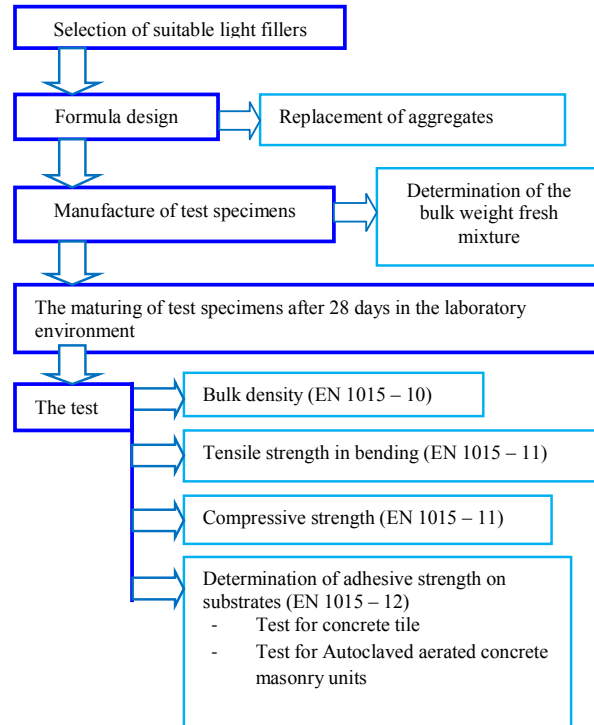


Fig. 2 Work methodology

### IV. SELECTED RESULTS

TABLE II  
THE RESULTS OF THE TESTS

Mixture	Bulk density 0 time / 28 days [kg.m <sup>-3</sup> ]	Tensile strength in bending x	Compressive strength max 2.5	Adhesive strength on substrates	
				Concrete tile	Autoclaved aerated concrete
*	0 / 400 - 480	x	max 2.5	0.3 – 0.5	xx
Ref	2187 / 1968	6.2	45.2	2.1	xx
A	734 / 548	1.2	3.3	0.554	0.249
B	824 / 587	1.1	4.1	0.587	0.255
C	673 / 605	1.1	3.0	0.761	0.347
D	712 / 521	1.4	3.0	0.647	0.369
E	989 / 736	1.6	6.1	0.619	0.287
F	912 / 687	1.4	5.4	0.873	0.369
G	643 / 502	1.0	2.3	0.554	0.249
H	627 / 489	0.9	2.8	0.587	0.322
I	563 / 435	0.7	2.5	0.592	0.351

\* note: limit values for use in aerated concrete

Of all the proposed formulas test specimens were produced

with dimensions 40 x 40 x 160 mm to be used in density [10], tensile bending strength and compressive strength tests [11]. Moreover, the designed repair mortar which was applied to the concrete tile and the autoclaved aerated concrete masonry units had the thickness of  $\pm 12$  mm for determining adhesive strength on substrates [12]. Values in the table are the average of the 3 test specimens.

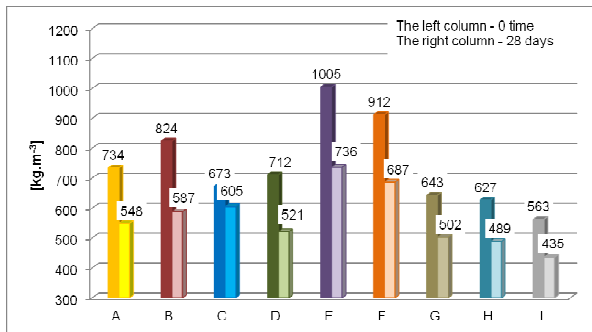


Fig. 3 The evaluation of bulk density

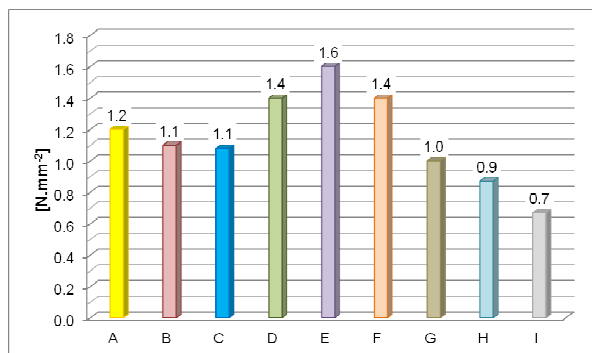


Fig. 4 The evaluation of tensile strength in bending

#### V. DISCUSSION

The light weighting of the mixture required the substitution of a standard-used filler (ground limestone and sand) for a lightweight one in order to enable its use in the sanitation of aerated concrete constructions. According to the results of all the tests, the most appropriate use of the repair mortar consisting of Poraver and Liaver aggregate is in reprofiling aerated concrete structures. These mortars display the required properties which were set as a limit for the application on aerated concrete at the beginning of the experiments.

The different values of adhesion on substrate during use on a concrete tile and aerated concrete brick are caused mainly by the low bending tensile strength of aerated concrete masonry units. The adhesion test with aerated concrete masonry units always resulted in pull-off of the dolly in the structure of the substrate.

Fig. 6 shows the structure of repair mortars containing the used lightweight fillers.

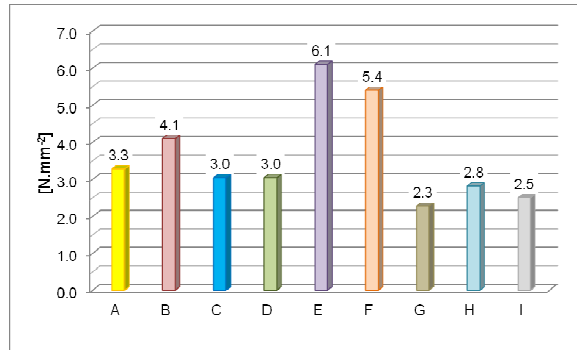


Fig. 5 The evaluation of compressive strength

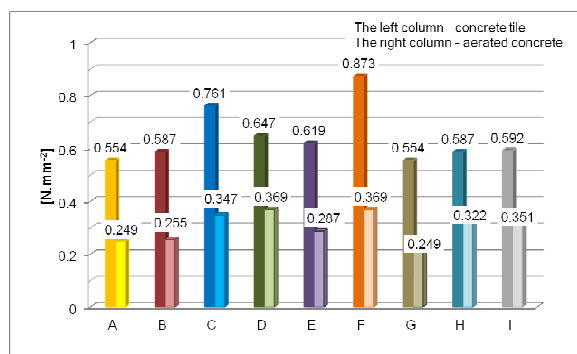
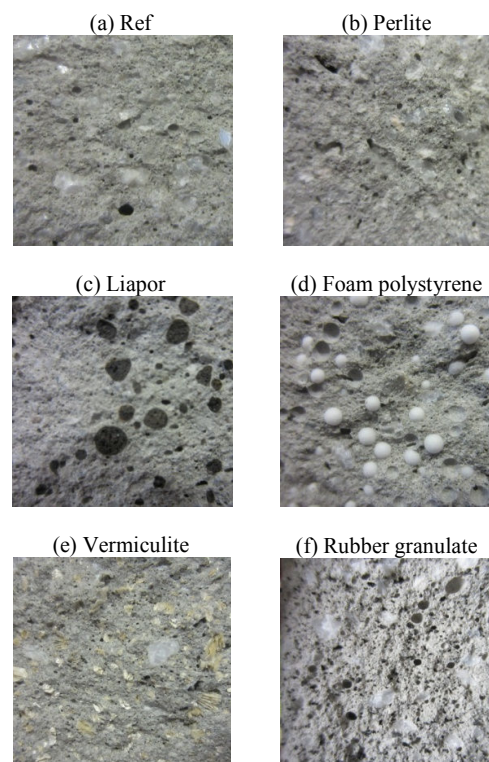


Fig. 6 The evaluation of adhesive strength on substrates



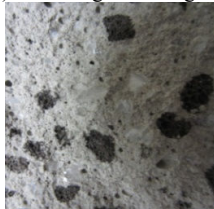
(g) HD-PE micro granulate



(h) Poraver



(i) Foamed glass Refaglass



(j) Liaver



Fig. 7 The sample structure of repair materials

## VI. CONCLUSION

The project implementation yielded the design and testing of a considerable number of materials consisting of lightweight fillers suitable for a variety of applications. The paper presents one direction of utilising lightweight aggregates in a polymer cement matrix which appeared as the most suitable to be introduced into practical application. The repair mortars useable for aerated concrete structures are not yet available in the Czech building material market for which reason it is a very promising product.

## ACKNOWLEDGMENT

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