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New screed materials for external thermal insulation composite systems

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Summary

Thermal insulation of buildings is an actual topic during present days when energy and fuel prices rise up. Thermal insulation of building facades consists from thermal insulation layer, its fixing and protective layer. This article is focusing the topic of reusing the waste for production of new polymercemente materials which can be used for such facades thermal insulation systems.

The goal of this work was to explore the possibility of using selected waste byproducts in the manufacture of new polymer-modified mortar – in particular, dry adhesives and screeding material to apply insulation sheeting materials in external thermal insulation composite systems, while at the same time maintaining the maximum possible filler for the desired characteristics.

In the course of the research, observation was made of the influence of the waste byproducts under study on mechanics and chemical characteristics that is to say on the microstructure of polymer-modified mortar adhesive and screeding mixtures. It is absolutely necessary to use computers for evaluation of results obtained during the performed tests.

KEYWORDS: External Thermal Insulation Composite Systems (ETICS), waste, recycling, polymercement mixture.

1. INTRODUCTION

The negative fallout from incautious handling of waste byproducts from human economic activity on the environment, as well as on man, provides good motivation to seek out new means of liquidating waste. Both ecological and economic reasons lead us to focus on the problem of waste in the building sector and how waste byproducts can be recycled in the manufacture of new construction materials.

The disadvantage of the polymer-modified mortar, which is currently available on the market, is its high price. This price is due chiefly to the use of expensive additives but high-quality compounds taken from non-renewable natural materials are also a factor. One possible way to postpone the exhaustion of non-renewable

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natural resources, and at the same time lower the price of production, is to take advantage of a wide range of waste byproducts, which are both high quality and carry a low price tag.

As high as possible ratio of recycled materials to be used, to prefer reusable sources and to keep as much supply of raw material for future [1] – those are the major directions towards to the main point of (SUR) Sustainable development in the Czech Republic. There is one possibility to keep the non-reusable sources (raw materials) to use secondary material sources e.g. waste material.

The Czech Law No. 188/2004 – Waste Operation Law shows how to solve this problems. This law prefers using so called material using of waste instead of other waste using. This article is giving an example how primary materials can be replaced by selected waste materials which can be considered as secondary material sources.

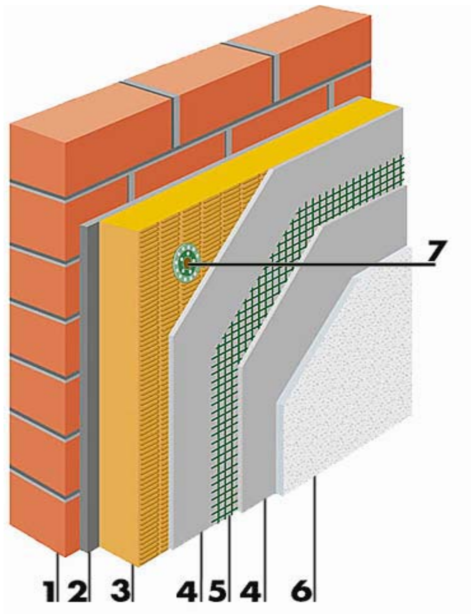
The results investigated and published by Czech Ecology Institute shows 37% of the whole amount of waste is reused as secondary material in the Czech Republic within present days. Building materials industry represents one of the branches which is able to use civil engineering waste and industrial waste as well.

2. THERMAL INSULATION COMPOSITE SYSTEMS

According to placement thermal insulation systems can be divided to exterior and interior. According to implementation and material solution they can be divided to plaster, prefabricated and contact solutions. Basic layers used in External Thermal Insulation Composite Systems (ETICS) see Figure 1 consists of base layer, glue/binding agent, thermal insulation, raw plugs, battens, reinforcement layer (reinforcement layer consists of screed and bracing mesh), surface treatment and auxiliary elements (auxiliary elements are the products for corners finishing, expansion joints, etc).

Binding agent is determined to affix thermal insulation on base. Screed mass and bracing mesh (bracing mesh is made of glass fiber usually) gives together reinforcement layer. In some cases according to manufacturer directions the screed layer can represent both binding agent and screed layer. Reinforcement layer is fundamental for securing mechanical properties, stability and service life of contact thermal insulation systems.

In this article the materials for fixing the thermal insulation layer and the materials for using as reinforcing layer were observed. Those fixing and kniffing materials are produced often as dry mix, during the production of dry mix is redispersible polymer added (as polymer part) into final material.



1 Masonry
2 Binding agent
3 Thermal insulation
4 Screed mass
5 Bracing mesh
6 Surface treatment
7 Raw plug

Figure 1. Basic layers ETICS [2]

3. SELECTED RESULTS

3.1. Used materials

Aggregate – crushed limestone, firestone sand, fly-ash, waste from crushed limestone flushing

Binding agent – cement CEM I 52,5 R

Additives – special admixtures named generally as additives. These contain redispersible copolymer EVA, stabilizing agent and defoamer

3.2. Observed properties

Main observed properties of screed and fixing layer observed during initial period were processability (according to Czech Standard ČSN 722441) and adhesiveness. Adhesiveness to concrete was measured according to Czech Standard ČSN 732577 and adhesiveness to polystyrene thermal insulation layer was measured according to Technical Rules - CZB 2001. Other observed values were strengths (according to Czech Standard ČSN EN 12808-3), frost resistance coefficient (according to

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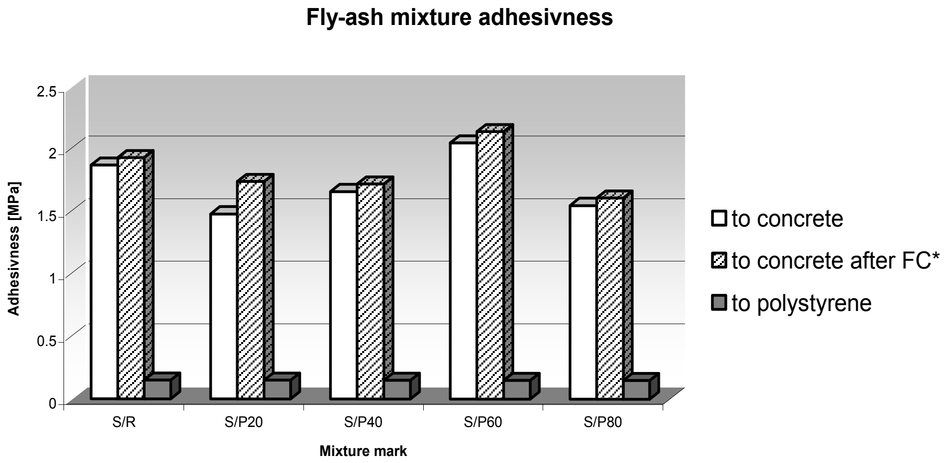
Czech Standard ČSN 722452) and thermal conductivity coefficient (according to Czech Standard ČSN EN 993-14).

The results acquired when gradually part of filling agent was replaced by fly-ash and after washing waste from crushed limestone, the quantity of 20, 40, 60 and 80% are showed on Figures 2 a 3. To have a comparison the mix with no waste material was tested – marked as S/R.



*FC – 25 Freezing Cycles

Figure 2. Fly-ash mixture adhesiveness

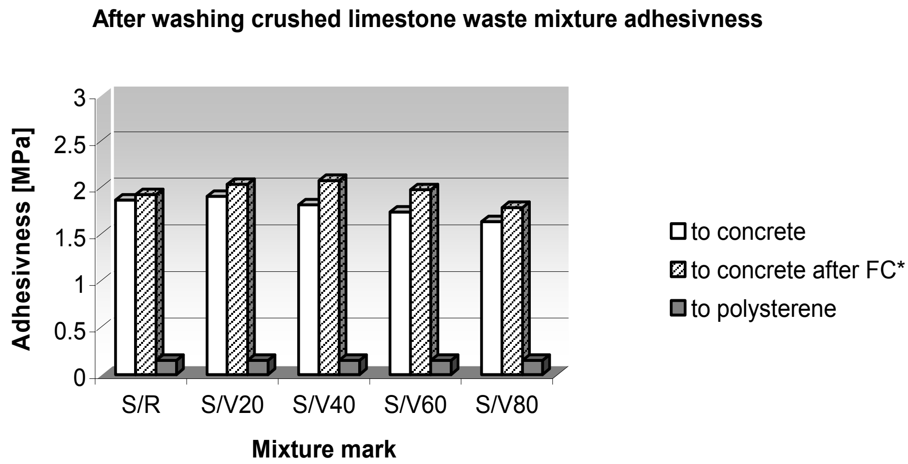


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Figure 3. Adhesiveness after washing waste from crushed limestone mixture

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Tests were realized with putty coats in order to clear also the fracture characteristic of these mixtures. This can be of importance for instance in the case of thermally stressed materials. The measured results are in the Table 1. This test was realized in cooperation with the Building Testing Institute at the Faculty of Civil Engineering, Brno University of Technology.

Table 1. Fracture characteristics

Mixture mark	Static modulus of elasticity E	Fracture toughness	Energy of the crak	Fracture performance
	GPa	MPa.m$^{1/2}$	J.m^{-2}	J.m^{-2}
S2	13,54	0,4928	19,43	11,72
S1	12,29	0,6718	36,74	23,55
S11	9,68	0,5734	34,01	22,50

The fracture characteristics are in particular the modulus of elasticity, the energy to fraction and the fracture toughness. The fracture characteristics complete the classical information concerning the material in form of strength characteristics. The fracture characteristics were determined by the analysis of data obtained by the Three – Point – Bending – Test (see Figure 2). The beams 40x40x160 mm were loaded by three points bending and in the same time the couples of load and deflection values were recorded [3].

Figure 2. Three-Point-Bending-Test

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The fracture toughness is a constant of the material or also the critical value at which the material will be failed before the front of the crack in the case of its unstable spread. This characteristic gives an account of the material properties in the area allocated by the increasing arm of the dependence between load and deflection. The higher is the load, the more resistant is the material against the spread of the crack.

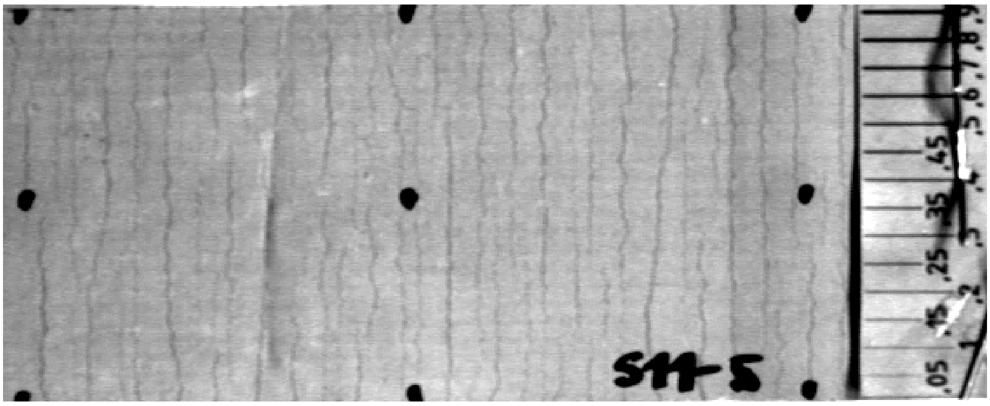

Figure 3. Reference screed mixture with elongation of 1.5% in the direction of the warp

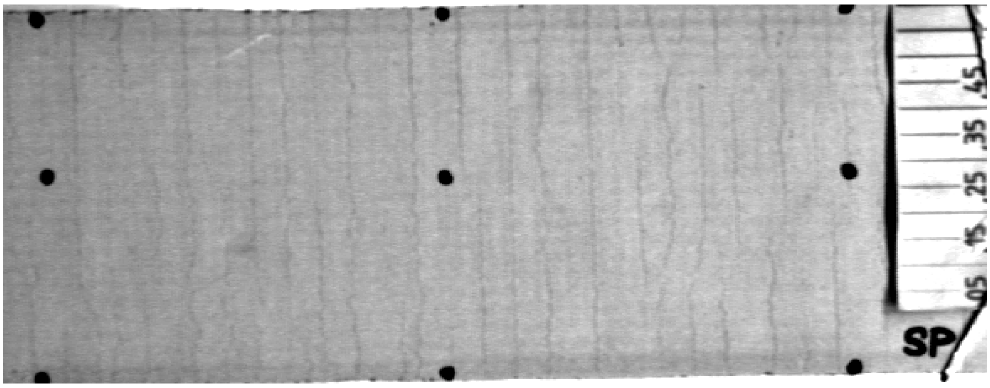

Figure 4. Screed mixture with s fly-ash (20%) with elongation of 1.5% in the direction of the warp

The mowing power is the energy necessary for the spread of the crack. The value of this energy depends on the fracture toughness and on the modulus of elasticity. The fracture performance represents the energy consumption during the process of fracture. The results in Table 1 show, that the most fragile material is the mixture S2, the parameters of mixtures S1 and S11 are almost identical.

The use of waste from crushed limestone washing and of fly ash can increase the adhesion especially after the freeze/thaw cycles, the compression and the bending strength, the frost resistance and the thermal conduction coefficient. The addition of fly ash can reduce the extent and the number of cracks. Figure 3 shows the reinforcing layer formed by meshwork and the reference putty coat (it contains only quartz sand and ground limestone) with elongation of 1.5%. The reinforcing layer with the meshwork and putty coat with the addition of fly-ash (20%) and also with the prolongation of 1.5% you can find in Figure 4.

The determination of cracks size in the reinforcing layer by the tensile test is for every tested mixture examined on six samples, (three samples in the direction of the warp and three in the direction of the weft). The formation of cracks and the cracks development was monitored for the given value of relative deformation. The Videoextensometer was used for the measurement and the archiving of the material surface actual state during the tensile test.

The principle of the measuring device is to pick up the visual field by the CDD camera and the digitalization of the image. The optical spots were monitored by the special software, which enables to examine the change of the plane coordinates spots [4]. The samples containing the fly ash showed a decrease of cracks frequency and size in the case of 0.5, 1.0 and also 1.5% prolongation in the direction of both the warp and the weft.

4. CONCLUSIONS

One can say, based on the results acquired in the frame of this article the selected waste materials as stated after washing waste from crushed limestone and power plant fly-ash can modify polymercemente stuff.

When the substitution of original material by waste material is appropriate the new material is having the same or even better properties than reference materials. New materials for external thermal insulation composite systems are ecologically and economically evidently beneficial.

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