Thermal Science and Engineering Progress 1 (2017) 59–65

Contents lists available at ScienceDirect

Thermal Science and Engineering Progress

journal homepage: www.elsevier.com/locate/tsep

Thermal and mechanical properties of gypsum plaster mixed with expanded polystyrene and tragacanth

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A R T I C L E I N F O

Article history:
Received 11 January 2017
Received in revised form 3 February 2017
Accepted 25 February 2017

Keywords:
Expanded polystyrene
Tragacanth
Gypsum
Insulation plaster

A B S T R A C T

In this paper, the employability of waste Expanded Polystyrene Foam (EPS) as filling material in the plaster with resin added gypsum by means of revaluation has been examined. After waste EPS is collected as packaging material and disintegration according to 0–3 mm particle diameters and mixed with the gypsum of percentages; 20%, 40%, 60% and 80%. Tragacanth is added to each of this binder at 0.5%, 1% and 1.5% of the weight of the mixture in order to create artificial pores on gypsum block. The samples of 16 different combinations are produces. They are subjected to some tests to find out their properties. It is found that; the thermal conductivity, the compression and tensile strength decreases with increasing amount of EPS and tragacanth in the mixture. Produced samples must not be used in external plaster which is subjected to water against the danger of freezing as the water absorption rate was found higher than 30%. With this study, it is recommended that the samples should be used as internal plaster, insulation plaster and decoration material due to their canal opening and paint sustention features. If this plaster and decoration material is used, (i) the waste EPS will be evaluated and environmental pollution will be prevented, (ii) building heating and cooling energy will be saved.

1. Introduction

The development of suitable construction materials can be listed as one of the difficulties for achieving energy consumption reduction in the buildings. One of these materials is gypsum plaster [1]. Gypsum plasters are widely used in building construction due to its ease of production, availability and low price. Nevertheless, the disadvantage of plaster are its brittleness, poor resistance to cracking and it is not suitable for outher plaster, as it cannot be used in damp situations [2]. Some of the researches on gypsum plaster are summarized below.

Mansour et al [1], studied on the Tunisian gypsum plaster (Meknassi region) which is ranks second worldwide for the production of gypsum. They found that the plaster exhibits an interesting behavior on the between thermal conductivity and temperature for buildings walls. Martias et al [2], investigated on the effects of the addition of glass fibers, mica and vermiculite to the mechanical properties of a gypsum-based composite at room temperature and during a fire test. Zhank et al. [3], prepared from flue gas desulphurization gypsum as thermal insulation gypsum plaster. In the meanwhile, the thermal conductivity is 0.18 W/mK. Naima et al. [4], studied the effects of dry-wet and freeze-thaw cycling on the thermal and mechanical properties of new straw-plaster composite materials proposed for building insulation. Karaipekli and Sari [5], have been mixed pumice-organic phase change materials-gypsum composite plasters and have been used for low temperature-thermal energy storage applications for passive solar heating, ventilating and air conditioning purposes in buildings. Khalil et al [6], determined the effect of some waste additives on the physical and mechanical properties of gypsum plaster composites. They were used blending plaster with 0.2–10% of unburnt rice husk, blast furnace slag, calcium carbonate or commercial poly vinyl alcohol polymer to gypsum plaster composites. Lanzon and Garcia-Ruiz [7], investigated the effect of citric acid on mechanical properties of gypsum building plasters. Belayachi et al [8], examined the effects of dry-wet and freeze-thaw cycling on the physical properties of new straw-gypsum composite materials for building insulation.

There are also studies subject to low density concrete liquids and below mentioned studies may be given as example.

Benazzouk et al [9], determined 470 W/mK and compressive strength 10.50 MPa in the sample with smallest thermal conductivity 50% rubber particle in the samples produced by using partial (30, 40, 50%) rubber particle instead of sand. Rim at al [10], in their studies, determined thermal transmission parameter in cement

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http://dx.doi.org/10.1016/j.tsep.2017.02.008
2451-9049/

Nomenclature

EPS	expanded polystyrene	ρ_{binder}	density of satin gypsum, (g/cm^3)
f_{ck}	compressive strength (MPa)	$\rho_{binder\ matrix}$	density of satin gypsum with 0% porosity ratio, (g/cm^3)
f_{ctk}	tensile strength (MPa)	W_k	dry weight of sample (g)
Φ	porosity, (%)	W_d	wet weight of sample (g)
ρ_{EPS}	density of EPS, (g/cm^3)	Z	EPS ratio (%)
$\rho_{EPS\ matrix}$	density of EPS with 0% porosity ratio (after milling and so causing no porosity), (g/cm^3)	(1-Z)	binder ratio (%)

+ clay + wood pellet (30%) composite as 0.140 W/mK and compressive strength as 1.35 MPa. Devecioglu and Bicer [11], by using expanded clay and tragacanth instead of sand in concrete, investigated the thermal and mechanical specifications of concrete. They determined smallest thermal conductivity as 0.182 W/mK in 20% expanded clay + 80% cement + 1% tragacanth sample and compressive strength as 1.48 MPa.

Utilization of EPS as construction material has been investigated in numerous researches. Many of these researches focused on the usage of EPS as a filling material in plaster or decorations and were presented below.

Doroudiani et al. [12] studied the environmental, health and safety problems of building reveal decorations made with EPS and made some recommendations. Mihlayanlar et al. [13], studied experimentally the impact of parameters and density of production process in EPS insulation panel production on the thermal and mechanical properties of the material. Kaya and Kar [14], investigated the physical characteristics of gypsum plaster with waste EPS aggregates. Gencel et al [15], have added expanded vermiculite and polypropylene fibers with low thermal conductivity to lightweight gypsum. Thermal and sound-proofing properties of the gypsum building materials can be improved by increasing the porosity by adding pore-forming agents such as inorganic ones. Kaya and Kar [16], in EPS + cement + tragacanth resin mixed composite material used instead of sand in concrete, smallest thermal conductivity is determined as 0.050 W/mK in EPS(80%) + cement (20%) + resin(1%) sample and compressive strength value as 0.89 MPa. Demirel [17], in his study, determined thermal conductivity in block sample composed of cement + EPS + pumice as 0.130 W/mK and compressive strength as 1.77 MPa.

In the present study, instead of conventional gypsum plaster, tragacanth resin (with adhesive characteristics) and EPS particles (as filling material) were added to gypsum plaster. Tragacanth absorbs water and swells when it is immersed in water. It loses this water during drying period which leads to the formation of artificial pores. Whereas these artificial pores augment total porosity of the material, they reduce its density. Samples prepared by using resin-added or regular plasters were subjected to thermal and mechanical tests and compared with similar materials.

2. Experimental

2.1. Materials

EPS is a thermoplastic material and has closed pores and a white color generally. It is consists of 98% air and the remaining portion is polystyrene [16]. The material is used for insulation purposes and in packaging of several products for protection purposes due to its flexible structure, impact absorption property and mechanical robustness. EPS is not poisonous; it does not perform chemical reaction under normal atmospheric conditions, it is not a nutrient for bacteria and fungi [16]. EPS is an environment-friendly material as it is a recyclable material and its components do not give harm to the nature and the ozone layer. Block EPS were disintegrated as 0–3 mm granule and used in the production of samples.

Tragacanth can be defined as a kind of glue oozing from the wounds inflicted on the *Astragalus* plant stem. Its color is white or light yellow, odorless and is in the form of circular plates or different shaped parts [18]. Tragacanth resin which is obtained dry is left in water and waited for 48 h for swelling and expansion; then it was knead and filtered to make a solution (Fig. 1). Finally it was added to the satin plaster at 0.5, 1 and 1.5% ratios.

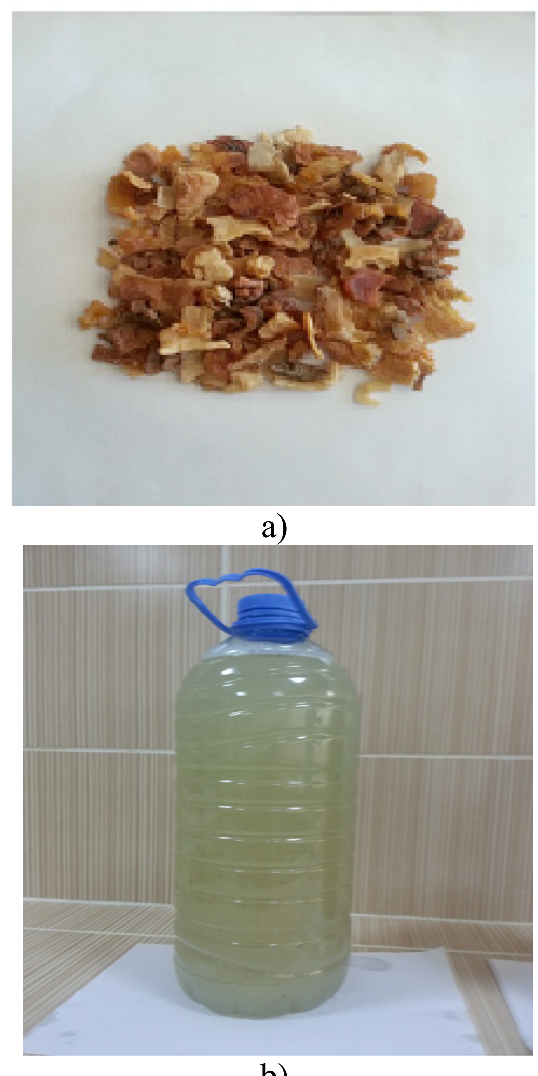

Fig. 1. a) View of dry tragacanth, b) extract resin.