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Technical Report

Mechanical behaviour and thermal conductivity of mortars containing waste rubber particles

Valeria Corinaldesi *, Alida Mazzoli, Giacomo Moriconi

Department of Materials and Environment Engineering and Physics, Università Politecnica delle Marche, Via Brecce Bianche, 60131 Ancona, Italy

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ABSTRACT

In the present paper an investigation of mechanical behaviour and thermal conductivity of a lightened building material containing either styrene butadiene rubber (SBR) or polyurethane (PU) waste particles or scraps coming from wasted rubber-shoe outsoles (SR, acronym of 'sole rubber') is presented. Several mortar mixtures were prepared by replacing quartz sand with 0%, 10%, and 30% of either SBR or PU or SR waste particles. The influence of rubber particle addition on fresh mortar behaviour, compressive and flexural strength of mortar as well as on mortar thermal conductivity was detected. An optimization of mortar mixture proportions was carried out by adding a limestone powder as filler. The experimental investigation showed that the addition of rubber particles reduces both the material unit weight and the thermal conductivity. The thermal insulating effect of rubber particles indicates a high and promising potential for future developments. On the other hand, the addition of limestone powder produced higher thermal conductivity as well as higher compressive and flexural strength.

1. Introduction

The reduction of energy consumption in construction, the production of thermally insulating materials and the solution of environmental problems by recycling of industrial and domestic waste are becoming a relevant problem. There are many lightweight composites that contain recycled fillers, including waste glass [1], fly ash [2–4], steel slag, lightweight crushed bricks, pozolanic materials [5–9], lightweight expanded clay aggregates [10], foam polystyrene [11]. Therefore, the development of composite construction materials with low thermal conductivity by using either styrene butadiene rubber (SBR) or polyurethane (PU) waste particles or scraps obtained from rejected faulty outsoles (SR) will be an interesting alternative that would solve simultaneously energy and environmental concerns.

Concerning the reuse of recycled rubber in mortars and concrete, extensive studies have been conducted on used tyre modified concrete and mortars [12–14]. The literature about the use of tyre rubber particles in cement-based materials focuses on the use of tyre rubber as an aggregate in concrete and evaluates only the mechanical properties. Results have indicated that rubberized concrete mixtures show lower density, increased toughness and ductility, higher impact resistance, lower compressive and splitting tensile strength, and more efficient sound insulation.

However, there are a few studies about the reuse of other plastic or rubber waste in lightweight aggregate concrete (LWAC) [15–22]. On the other hand, there is worldwide environmental, economic, and technical incentive to encourage the structural use of LWAC [23–25]. LWAC has been used successfully for structural purposes for many years. For structural applications of lightweight concrete, the structural efficiency is more important than the absolute strength level. A decreased density for the same strength reduces the dead load, foundation size, and construction costs. With the rapid development of concrete technology in recent years, high-performance concrete has been produced more easily. Since 1980, several investigations on high-performance lightweight concrete have been reported [26–29].

In the present paper an attempt was made to prepare cementitious (lightweight if possible) mortars by adding to the mixtures either styrene butadiene rubber (SBR) or polyurethane (PU) waste particles or scraps from rejected rubber-shoe outsoles (SR, acronym of 'sole rubber').

Polyurethane waste particles as well as rejected shoe soles (made of polyurethane and SBR) were supplied by a factory producing rubber soles for the footwear industry. In 2007, the shoes factory produced about 250 tonnes of polyurethane waste particles at all, amount corresponding to the 18% of the overall production. The 24% of these 250 tonnes (corresponding to 60 tonnes per year) is due to rejected outsoles, another 24% is due to production leftovers and the remaining 52% is produced by the continuous changes of colour and type of materials in order to follow the developing market demand.

* Corresponding author. Tel.: +39 071 2204428; fax: +39 071 2204729.
E-mail address: v.corinaldesi@univpm.it (V. Corinaldesi).

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