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Experimental testing suitability of the waste glass into the polymer anchor materials based on epoxy resin

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Abstract

This article deals with the suitable use of waste glass in polymer anchor materials based on the epoxy resin. The research focused on the effect various waste glass had in different amounts on specific anchor-material properties. Various tests were conducted such as the specification of tensile properties, thermal resistance, monitoring the temperature during a polymerization process and a pull-out test. Test results assessment led to choosing a formulation that would yield the best quality of the polymer anchor.

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Keywords: polymer anchor; epoxy resin; waste glass; pull-out test; glass transition temperature; tensile strength; microstructure

1. Introduction

The aim of this research is to prove the suitability of using waste glass in polymer anchor materials. Considering the significant amount of waste glass that is produced during the use, generation and recycling of various types of glass, there is an effort to gain the highest level of anchor material filling. Waste glass comes from various industrial sectors, including the food, chemical, electrical engineering and automotive industries. The most commonly used types of waste glass is packaging glass, auto glass, solar glass, molten glass, strip light and light bulb glass and fibreglass.

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The use of waste glass in polymer materials was investigated by Saribiyik et al. [1], who tested the use of waste glass in polymer concrete. The use of waste glass leads not only to the improvement of material quality, but also delivers economically viable primary materials (polymer materials, quartz sand), as well as environmentally-friendly treatment.

Prior to use as filler, all types of waste glass must be properly processed. This primarily concerns the removing of undesirable materials, components and foils, and a follow-up process of granulometry. The glass is then crushed, milled and dried according to the desired particle size. Waste glass is suitable filler due to its high silicon dioxide content, which has impeccable physical and mechanical properties and good chemical resistance. Epoxy resin-based anchor materials have the best quality among anchor materials and are used in various industrial operations for complex the anchoring of heavy devices, in both fissured and not fissured concrete. Anchor materials have high firmness, very good chemical and thermal resistance and minimal contraction ability [2].

Barnat et al. [3] defined the firmness of inbuilt epoxy resin-based anchors in experimental and numerical research on their effect on the firmness of a material joint. Very good adhesion of a chemical anchor material to concrete is necessary for the absolute chemical functioning of an anchor, which was also addressed in experimental research by Bajer et al. [4], who tested the reaction of concrete on a chemical anchor material.

An important parameter of epoxy resin-based anchor materials is the glass transition temperature (Tg). Tg is determined primarily by two methods: differential scanning calorimetry (DSC) and Dynamic Mechanical Analysis (DMA). Both methods for determination of Tg were used in experimental research by Zhou et al. [5], who tested the effect of hydrothermal epoxy resins. During this experiment, the traction ability of developed anchor materials was also tested, focusing on the highest firmness in a contraction and its corresponding proportional lengthening. A similar experiment by Akderya et al. [6] focused on the effect of aging on the contraction ability of epoxy resins.

2. Identification of the materials

Overall, three types of waste glass were chosen for testing the suitability of waste glass use in epoxy resin-based polymer anchor materials. The chosen types for testing were transparent packaging glass, auto glass and solar glass (type QS). Siliceous sand Dorsilit were used as reference filler.

2.1. Waste glass

All the waste glass had to be crushed and ground and any supplements and impurities had to be removed. The transport and preparation of auto glass was extremely difficult because of its safety plastic film, toning ironwork, various sensors, cameras, heating lines and stripping. Solar glass (type QS) is the type of the most widespread solar panel and consists primarily of amorphous silicon. It is necessary to remove the ethylene vinyl acetate (EVA) foil before use, which is mainly done via a thermal or mechanical-chemical method. The glass is then crushed and milled according to the desired fraction. The following table (Table 1) includes the chemical compositions of the waste glass. Granulometry of all the fillers alongside percentage ratios of the fractions is stated in the Table 2. Table 3 shows a density of the waste glass that were tested by the gas pycnometer.

Table 1. Chemical composition of the waste glass

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	BaO	TiO_2	ZrO_2	MnO
Auto glass	69.16	0.69	0.14	9.19	3.71	0.32	12.00	0.17	0.03	0.03	0.01
QS Solar	71.00	0.49	0.11	8.45	4.04	0.17	12.40	0.01	0.02	0.01	0.01
Container glass	72.00	2.52	0.04	7.32	2.04	0.30	14.42	0.00	0.01	0.00	0.00

Table 2. Granulometry of the fillers (waste glass and reference siliceous filler).

Size fractions [mm]	0-0.1	0.1-0.315	0.315-0.63
Amounts [%]	5	50	45