STUDY OF MECHANICAL PROPERTIES OF PROTECTIVE MATERIALS USING WASTE RAW MATERIALS

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Abstract- Polymer based materials are at present very often used for protection of horizontal constructions from corrosion caused by different effects. They are applied as early as with construction as preventive protection but also during reconstructions and repairs as repair and mending materials and they may have not only protective function but also aesthetic and technical ones like for instance industrial floors.This article describes the results of the research of new polymeric materials using waste raw materials which has been taking place at Brno University of Technology, Faculty of Civil Engineering. These polymeric materials with substitution of common fillers by waste materials must meet mechanical properties like flexural and compressive strength.

Keywords- Protective material, polymer, waste, secondary raw material, filler, binder.

I. INTRODUCTION

Since with the growing industrial production also the quantity of generated industrial waste has still been growing it is necessary to utilise these wastes and prevent their disposal at landfills together with their negative impacts on the environment. The use of waste materials has also significant positive effect on saving of natural raw materials whose resources constantly decrease.
And last but not least we can positively consider also the economic effect - for producers the costs are lower when they supply waste materials to customer than to dispose them at dumping grounds and also consumer will save with waste materials compared to natural ones. This should result in product lower final price for the consumer of waste, therefore the producers of building materials and products and at the same time the increase of competitive strength within particular activity field.

The objective of this research and development taking place at Brno University of Technology, Faculty of Civil Engineering is to find new progressive protective means for horizontal concrete constructions using waste materials. Within the ongoing works we are involved in verification of possibility to incorporate waste raw materials in water-soluble and solvent-free materials.

Introduction of such a product in standard production is entirely innovative, however, only suitable secondary raw materials must be selected for such products and properties of materials produced in this way must be checked. Selected secondary raw materials substitute common fillers by which the price for protective means should drop and

mechanical and eventually other material parameters should be preserved or improved.

II. SELECTION AND PREPARATION OF POLYMER SYSTEM COMPONENTS

2.1. Selection and preparation of binders

Polymeric binders consist of basic matrix (component A), i.e. some suitable polymer (epoxy resin in our case) and suitable cross-linking agent (component B). Component A gives mainly the polymerisation speed to the system and then provides mechanical and other parameters to final polymer. Application properties as system rheology, substrate wetting, chromacity, covering forces, filling etc., are subsequently determined by added additives, fillers and pigments. Component A then may include approximately 5 – 30 components. Component B functions only as cross-linking agent providing polymerisation and hardening of entire system. If fillers are part of component A, they used to be mostly bi-component materials. If the fillers are added additionally to the system during mixing, the materials may be even three-component.
For the purpose of the solution of our project two coating polymeric materials were selected, both based on solvent-free basis (marking ON-E, ON-P). Both of these binders should provide properties of final material in order these materials are applicable for anticorrosive and chemical protection of steel constructions, interior and exterior surfaces of supply bin external parts for chemicals and interior and exterior protection of concrete sedimentation tanks, sewage plants, sumps etc. In case of binder for material ON-P it should also provide high chemical resistance.

2.2. Selection and preparation of fillers

Within the research carried out as part of the solution of the experimental project, waste raw materials were selected that could be used as fillers in the developed polymeric materials. Wastes with SiO_2 content occurring within entire CZ territory were considered. The prepared research of wastes usable as secondary

raw materials became the base for further process - the selection of the most suitable fillers substitutes. 12 wastes in total were selected and were used as fillers in polymeric protective materials for horizontal concrete constructions.

III. METHODOLOGY OF FORMULA DESIGNS

The formulas were designed as complete substitution of common fillers. Ideal result is a substitute in the same or higher amount of fillers compared to reference comparison materials. The higher filler content in polymeric material the lower need of binder and whole system become more economic. However, the content of fillers may negatively influence properties of resulting materials.

Application test was carried out in order to determine maximum possible amount of fillers in developed materials. This test is being monitored:

1. Workability at the moment of mixing of fillers and binder components. It is evaluated if the materials can be easily and well processed (mixed) and if particular components of filler, binder and hardener materials are well mixed and whether this processing is not time and technically demanding.
2. Applicability on cement particle boards. During the application of the materials it is evaluated whether it is possible to apply the materials using required technology recommended by the producer, what are rheologic properties of the system, compatibility of binder component and fillers and whether final surface is wholly fused and levelled.
3. Evaluation of final surface is made with polymerised mixture. It is evaluated if the material meets the required requirements for quality of final surface which should be smooth, glossy, without defects, no stains, indentures should occur and also fillers would not separate from binder component.

The results were compared with reference comparison mixture and best formulas with highest filler content were selected for further testing. Example of satisfactory and unsatisfactory surface of polymerised mixture can be seen in Fig.1 and Fig.2.

Fig.1. Example of satisfactory surface of ON-E material

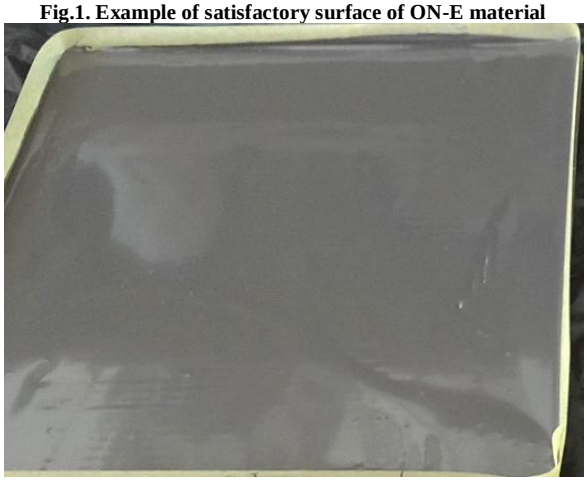


Fig.2. Example of unsatisfactory surface of ON-E material

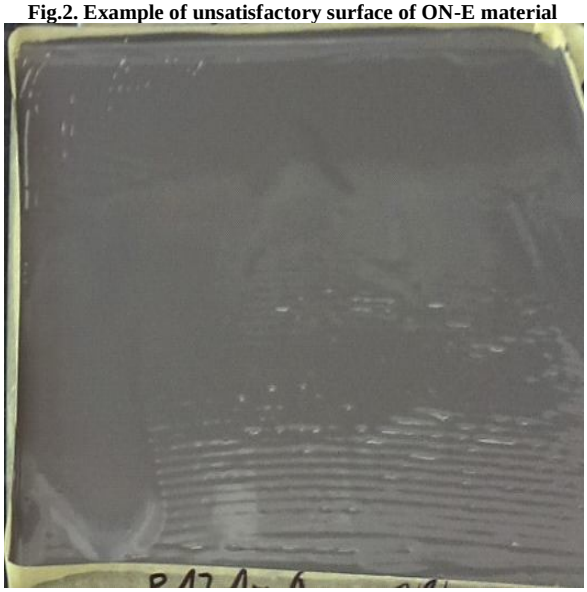


Table 1:Best selected formulas

Waste	Filler content in the material	
	ON-E	ON-P
Balotina	25%	15%
SIMAX	---	15%
Carglass	25%	20%
Container glass	25%	15%
Photovoltaic panel QS	15%	---
Tubular solar panel (dark glass)	20%	---
Tubular solar panel (light glass)	20%	20%
Photovoltaic panel LDK	---	15%
NaSX	20%	---

Some of the selected waste raw materials did not pass at all, some of them are suitable only for one of the developed materials.

IV. SETTING OF STRENGTHS

This test was carried out according to ČSN EN 13892-2 Methods of tests for screed materials – Part 2: Determination of flexural and compressive strength. This standard defines the method for determination of flexural and compressive strength on specimens prepared among others also from resin screed materials. The test is based on calculation of strength from stress resulting in break of samples.

4.1. Tensile flexural strength

Tensile flexural strength of developed materials should be equal or higher that tensile flexural strength of comparison reference mixture.

Fig.3. ON-E flexural strength results

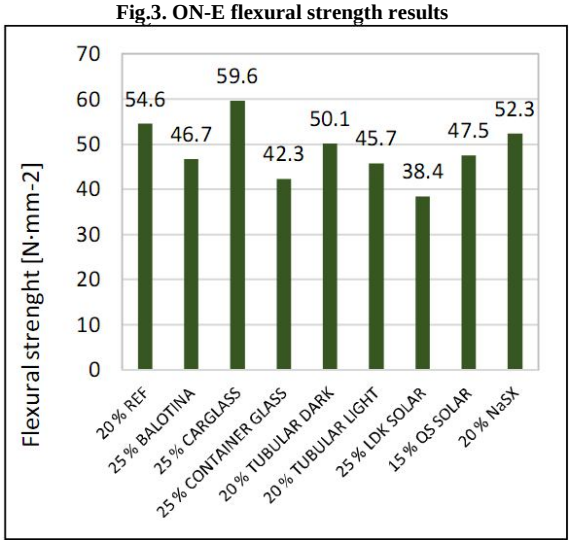
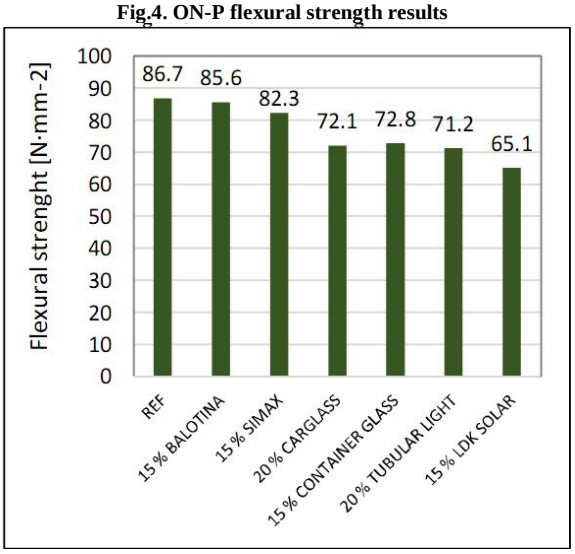


Fig.4. ON-P flexural strength results



4.2. Compressive strength

Compressive strength of developed materials should be equal or higher than compressive strength of comparison reference mixture.

Fig.5. ON-E compressive strength results

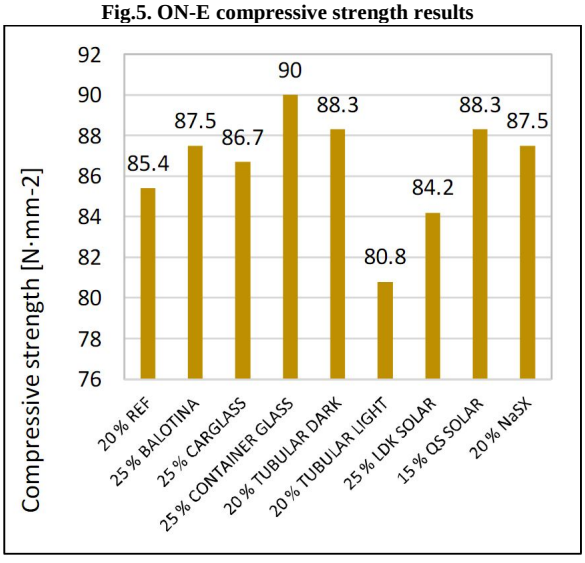
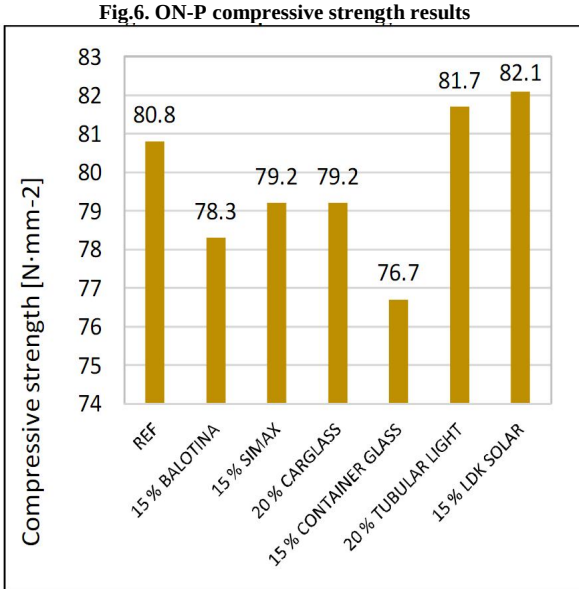


Fig.6. ON-P compressive strength results



4.3. Summary of results

The flexural tensile strength test were met only by few suggested formulas which met the requirement to obtain minimally those values like comparison reference mixtures. During comparison not only resultant values but also dependence on filling must be considered. If any of the mixtures with high filling (for instance 25%) gets slightly lower strength values like similar mixture with lower filling (for instance 20%), it is economically more convenient while sufficient values are preserved - however the condition of min. values still applies (equal to values of comparison reference mixtures).

In connection to the above state the best formulas were ON-E filled with 25% carglass and ON-P filled with 15% balotina.

V. FINDINGS

On the basis of obtained results it can be said that it is possible to use waste materials as fillers for polymeric protective systems. It is important that required mechanical properties of these materials remain preserved. If the developed materials are intended for application as repair or reconstruction materials, we can follow during their application the standards and instructions:"Technical Conditions for Rehabilitation of Concrete Constructions TP SSBK III“. Here the conditions of strength min. values for flexural strength are > 5,5 MPa and compressive strength > 25 MPa and < 50 MPa. The materials which were selected in the end of this phase for further testing met these conditions and mostly exceeded the required values.

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