TECHNOLOGY OF GFRC PRODUCTION WITH WASTE MATERIALS UTILIZATION

René Čechmánek [1], Michal Šotek [2], Stanislava Schierová [3]

Abstract

Shell concrete elements reinforced with alkali-resistant glass fibres combine a range of very advantageous qualities, esp. high flexural and impact strength. They have a lot of benefits, among others they minimize production, transport and assembly costs, and save the environment as well. Due to utilization of various kinds of waste materials it is possible to reduce also raw materials costs and save natural resources of raw materials, which are used for concrete production nowadays. We can also achieve significantly better properties of mentioned elements in comparison of a current level.

Keywords: GFRC, waste, slag, strength, durability, porosity, ecotoxicity

1 Introduction

Glass fibre reinforced concrete (GFRC) is a fine-grained concrete with a matrix based on high-valuable Portland Cement. A slight profile with thickness about 10-15 mm is achieved by addition of alkali-resistant glass fibres. GFRC elements find today increasingly broader possibilities of improvement in all spheres of building industry: especially facing panels, U-shaped gutters for high-voltage cables up to various shaped architectural elements.

2 Technology of GFRC production

2.1 Spraying technology

GFRC producers in the Czech Republic use mainly a spraying technology. It means that a glass fibre roving is chopped into individual fibres and implemented into a sprayed cement-sand wet mixture.

1) Research Institute of Building Materials, Hněvkovského 30/65, 617 00 Brno, Czech Republic, e-mail: cechmanek@vustah.cz
2) Research Institute of Building Materials, Hněvkovského 30/65, 617 00 Brno, Czech Republic, e-mail: vustah@vustah.cz
3) Research Institute of Building Materials, Hněvkovského 30/65, 617 00 Brno, Czech Republic, e-mail: vustah@vustah.cz

- cement CEM I 52,5 47,25%
- fine-grained aggregate 47,25%
- plasticizer 0,50%
- alkali-resistant glass fibre 5,00%
- water/cement ratio 0,4

2.2 Premix technology

Our research institute has recently developed new technology, so called premix. An exact amount of glass fibres is added into fine-grained matrix in the last stage of mixing and in this way properly dispersed in whole volume.

- cement CEM I 52,5 53,2%
- fine-grained aggregate 40,0%
- fine admixtures 3,0%
- super-plasticizer 0,8%
- alkali-resistant glass fibre 3,0%
- water/cement ratio 0,3

2.3 Comparison of GFRC technologies

Final characteristics of these composites are mainly flexural strength, impact strength, bulk density, absorptivity and frost resistance. Comparison of characteristics of sprayed GFRC, premix and hybrid-fibre premix with combination of dispersed fibres and a mesh fabric is shown in following table:

Characteristic	**spraying technology with 5% fibres**	**premix with 3% fibres**	**premix with hybrid-fibres**
flexural strength (MPa)	11	11	16
flexural proportional limit (MPa)	7	8	12
flexural modulus of elasticity (GPa)	15	15	18
impact strength IZOD (kJ/m^2)	5	5	8
bulk density (kg/m^3)	1950	2050	2050
absorptivity (%)	15	10	10
moisture length changes (mm/m)	1,5	1,5	1,5
frost resistance after 50 cycles (%)	80	100	100
fire resistance	A1		

Fig. 1 Characteristics of GFRC

3 Possibilities of GFRC mixture modification

GFRC elements can be exposed to various weather conditions, frost and defrost effects or various kinds of aggressive substances. Dense structure for these influences is achieved by fine admixtures addition, e.g. silica fume or meta-kaolin. These admixtures also reduce a free lime and an efflorescence on concrete surfaces as well.

4 Utilization of waste materials

Present trend in developed countries is utilization of secondary raw materials in bulk as possible. An insufficient utilization in the Czech Republic in last years was caused mainly due to lower price of waste deposition in comparison to recycling cost. Nevertheless high volumes of industrial waste materials in our country represent a great potential, which is not adequately exploited so far. Main sphere of the waste materials utilization is estimated in a building industry.

In the frame of research aim *MSM 2623251101 "Research of Ecological Treatment of Industrial Waste Materials"* of Ministry of Education, Youth and Sports of the Czech Republic our research institute uses e.g. blast furnace slags, furnace clinkers, ashes and fly ashes with technological, ecological and economical aspects.

4.1 Comparison of samples without and with waste materials addition

- spray – sprayed GFRC before durability test
- spray/20 – sprayed GFRC after durability test (20 years simulation)
- premix – GFRC premix before durability test
- premix/20 – GFRC premix after durability test (20 years simulation)

- slag 7 – slag addition 7% per weight of a dry mixture based on White Portland Cement before durability test
- slag 20 – slag addition 20% per weight of a dry mixture based on Portland Cement before durability test
- slag 25 – slag addition 25% per weight of a dry mixture based on Portland Cement before durability test

- slag 7/5 – slag addition 7% per weight of a dry mixture after durability test (5 years simulation)
- slag 7/20 – slag addition 7% per weight of a dry mixture after durability test (20 years simulation)

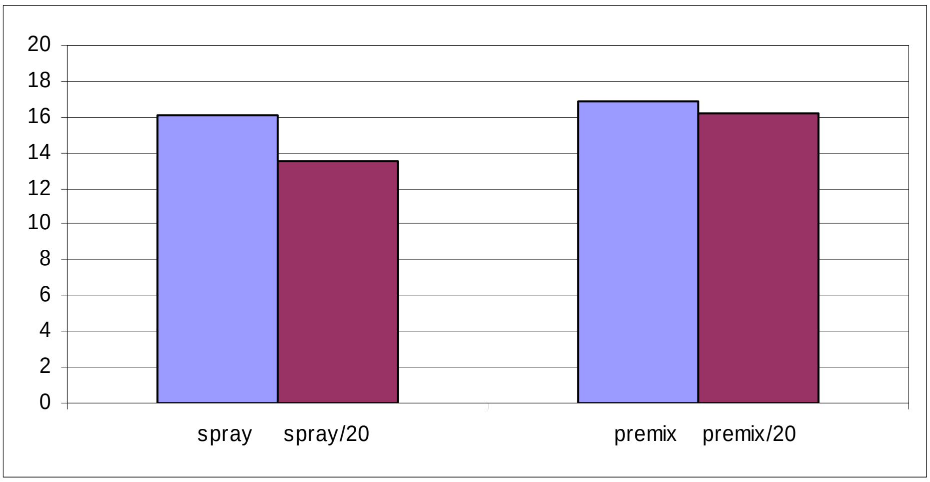

Fig. 2: Flexural strength in MPa of GFRC samples before and after durability test

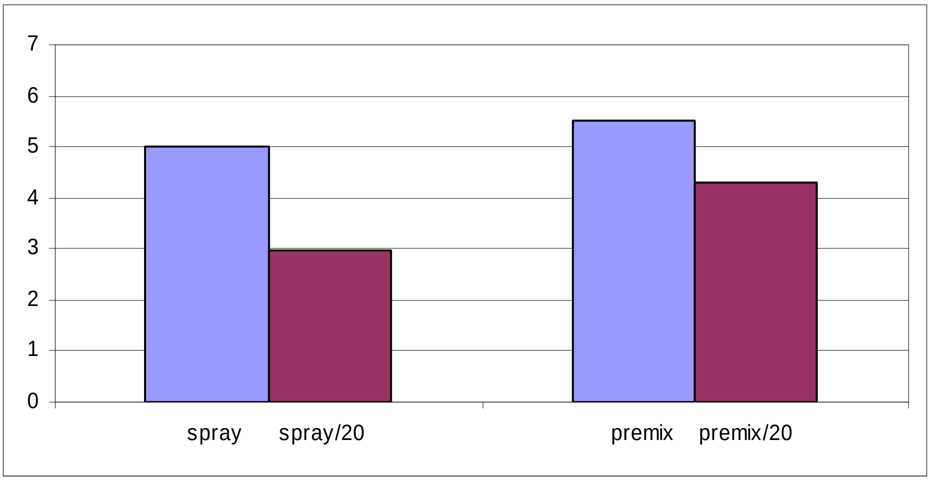

Fig. 3: Impact strength in kJ/m^2 of GFRC samples before and after durability test

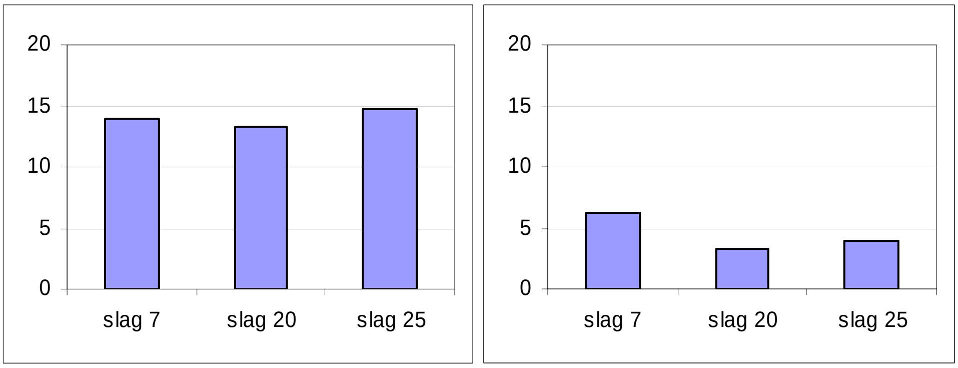

Fig. 4+5: Flexural and impact strength of GFRC with various addition of slag

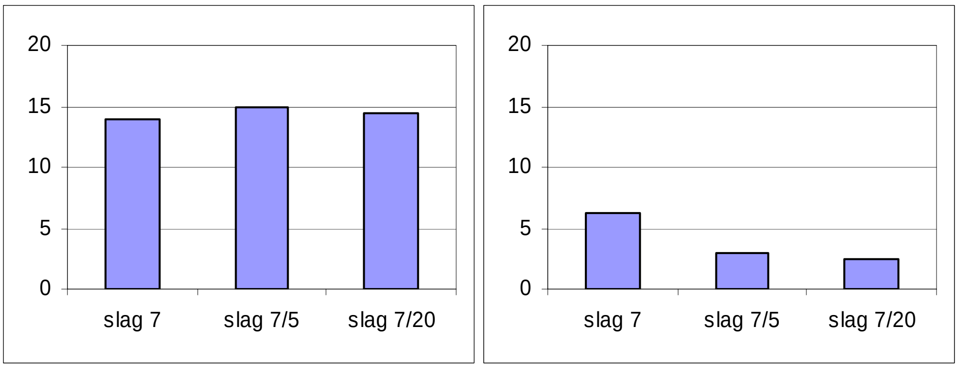

Fig. 6+7: Flexural and impact strength of GFRC with addition of slag after durability test

4.2 Porosity evaluation

Besides RTG diffraction analysis of a quality phase structure and differential thermo analysis of an individual composition components quantity was observed also a porosity of samples.

Sample	spray	premix	slag 7	slag 20	slag 25
Total porosity (cm^3/g)	0,0794	0,0671	0,0640	0,0466	0,0182

Fig. 8: Porosity of samples without and with addition of slag

4.3 Ecotoxicity evaluation

Ecotoxicologic tests serve to determination of a possible negative influence of tested materials to organisms. Selected organisms are exposed to a water leach from individual materials. Representatives of the ecosystem are: vertebrates - *Poecilia reticulata*, invertebrates - *Daphnia magna*, superior plants - *Sinapis alba* and unicellulars - *Scenedesmus subspicatus*.

4.4 Dimension stability evaluation

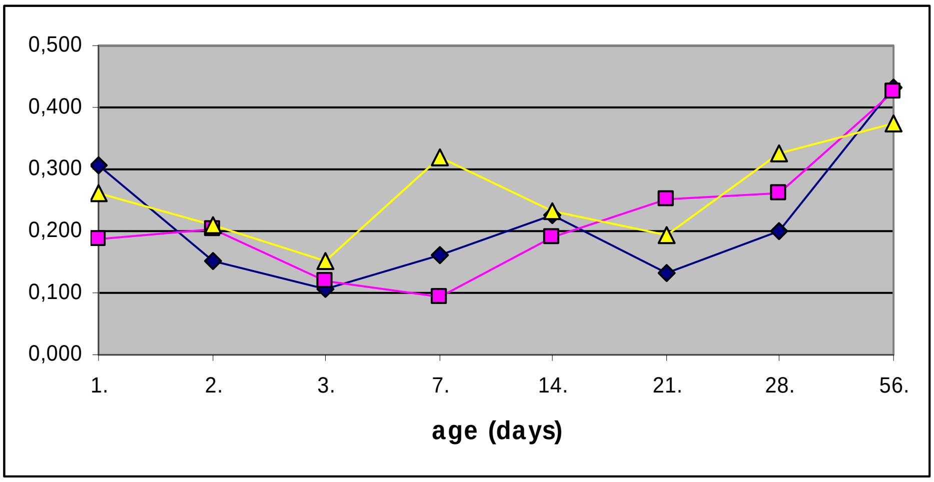

Fig. 9: Length differences of GFRC without addition of slag at various ages

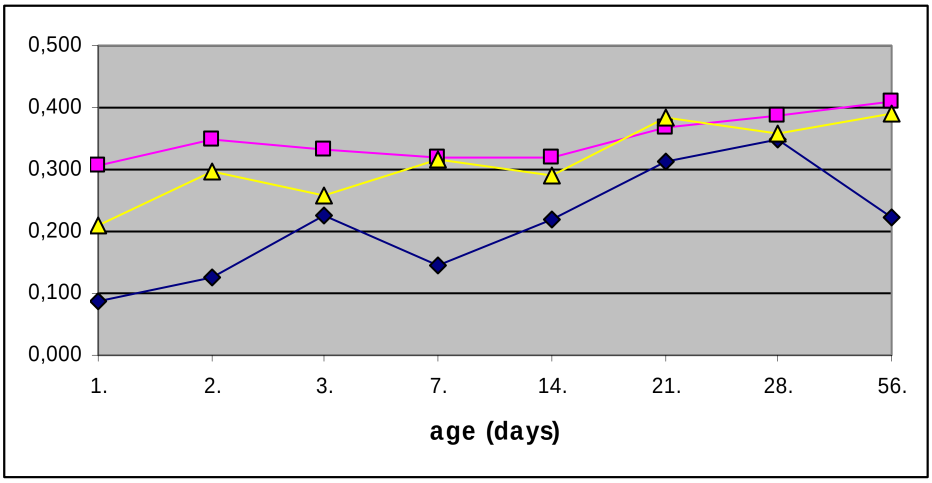

Fig. 10: Length differences of GFRC with addition of slag at various ages

5 Conclusion

In this contribution were presented only particular results from our research. Nevertheless the positive influence of the blast furnace slag addition to the GFRC matrix was observed. An optimal substitution of cement, aggregates and fine admixtures with slag assure at least the same strength level and in some case also a lower porosity level. The slag addition doesn't influence the dimension stability and the ecotoxicity of GFRC elements as well. Utilization of these waste materials has therefore a positive impact to the environment.

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