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Influence of Specimen Shape on Compressive Strength of Gypsum Composite Reinforced by Recycled Wires

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Abstract: The purpose of this study was to deeply investigate the influence of the tire wires on the behavior of brittle material and size effect for such material. To that purpose, gypsum was chosen as an appropriate model material. There have been two different sizes of the tested specimens and the reinforcement was placed and compacted using various techniques.

Keywords: Gypsum; Recycled Wires; Shape; Compressive Strength; Reinforced Composites.

1 Introduction

The tendency to reuse and recycle old materials is reflected, as in other areas, also in construction industry, not only for environmental, but also for economic reasons. Stabilizing of subsoil under railway using grout produced from finely ground old railway sleepers seems to be very perspective because the material does not need be to be transported to the site [1–3]. Moreover, the subsoil can be reinforced by dispersed PET fibers. Such technology has been already adopted when reinforcing cement-based composites [4, 5]. The pioneering study also demonstrated that recycled wires from disposed automobile tires can significantly increase ductility of such brittle materials for a relatively low cost [6].

2 Tested Samples and Experimental Methods

The prismatic specimens of dimensions 40 × 40 × 80 mm were prepared in two configurations: the reference samples without reinforcement (denoted as Reference-P) and reinforced ones (Reinforced-P). Cylindrical molds were used for another set of specimens, having their diameter equal to 100 mm and a height of 120 mm. The cylindrical specimens were also prepared as a plain reference material and a reinforced one, denoted as Reference-C and Reinforced-C, respectively. The specification of the tested samples complemented with the data describing the amount of wires and bulk density is provided in Tab. 1.

Grey (plaster) gypsum from Gypstrend, s.r.o. was used for the study, the water to gypsum ratio for all samples was equal to 0.71. All the prepared samples were tested 28 days after their preparation. The recycled tire wires were placed into the molds in layers and compacted in such a way that the wires were aligned with the top edge of the molds. Such approach was addressed based on previous experience with similar materials such as reinforced cement pastes [7–9].

Tab. 1: Specification of tested materials (magnitudes are complemented with standard deviations).

Set	Reinforcement	Amount of wires [%]	Bulk density [kg/m^3]
Reference-P	none	none	1004 ± 8 %
Reinforced-P	recycled wires	20	1142 ± 10 %
Reference-C	none	none	1070 ± 10 %
Reinforced-C	recycled wires	23	1275 ± 12 %

Tab. 2: Comparison of mechanical properties for various material configurations.

set	width / length ratio	compressive strength [MPa]	standard deviation [MPa]
Reference-P	0.5	2.4	$\pm$ 0.5
Reinforced-P	0.5	2.1	$\pm$ 0.3
Reference-C	0.8	2.0	$\pm$ 0.2
Reinforced-C	0.8	3.3	$\pm$ 0.2

3 Experimental Results

Based on the experimentally obtained data (Tab. 2) there is an obvious difference in the material behavior with respect to the tested specimen shapes (Fig. 1), [6]. The plain reference material exhibited 0.25-times lower strength than the reinforced samples. The reduced strength of the prismatic specimens, in comparison with the cylindrical ones, is attributed to imperfect distribution of the reinforcing wires across the cross-section as demonstrated in Fig. 2 and 3. The specimens lacking any reinforcement exhibit a very brittle behavior, even when compressed. After the initiation of first cracks the specimen disintegrates immediately and loses its stability. A completely different behavior can be observed in the case of wire-reinforced material that, after the initial localized cracking exhibits hardening and more energy is required for complete failure. However, the rubber residues and interconnection of wires makes the material inhomogeneous even at macro scale.

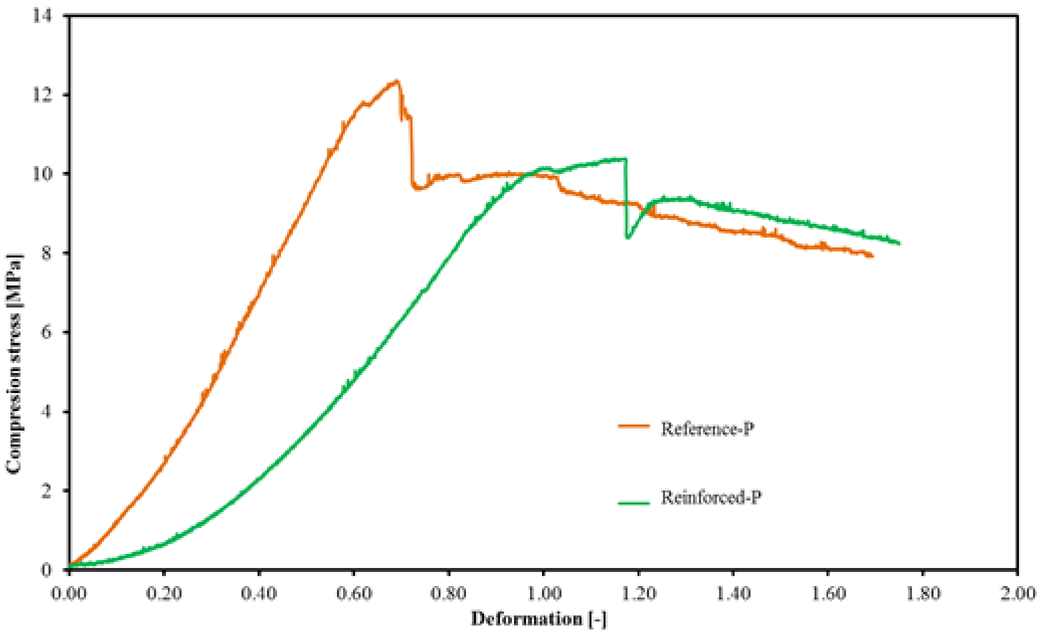


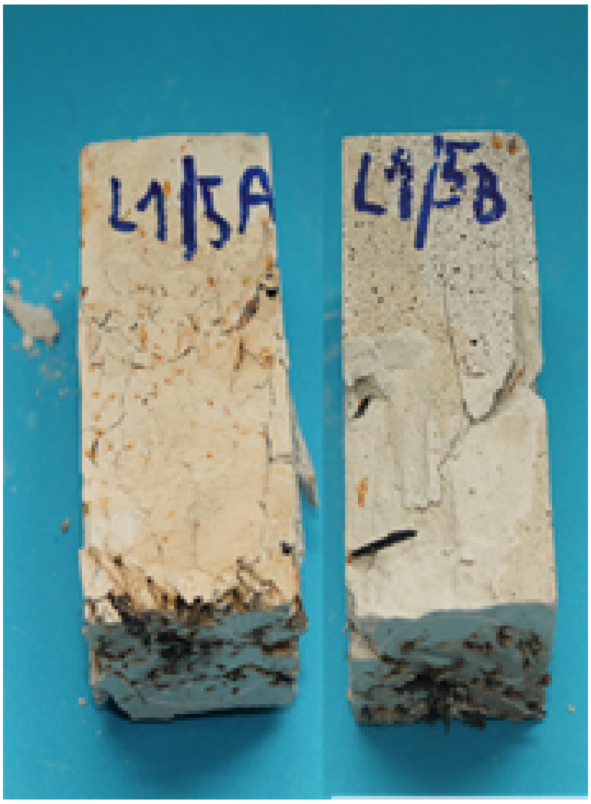
Fig. 1: Comparison of mechanical properties for typical prismatic reference and reinforces samples.

In our specimens, the higher concentration of wires in the core of the prismatic shape was probably associated with improper compaction of the matrix (which is reflected in lower density of the material compared to the cylindrical specimens) and therefore also their reduced strength by 0.3 MPa with respect to the plain reference material. The reinforcement quality (mainly the amount of rubber residue) and the dominant direction of the wires also determines the properties of the composite. Also better interconnection of the wires in the case of cylindrical specimens, due to their bigger area, probably contributed to the significantly enhanced strength, Fig. 1, 2.

4 Conclusion

The results of the presented study indicate that the recycled wires from disposed automobile tires can be efficiently used as a dispersed reinforcement, e.g. in the case of deformation absorbers. In such a case the

(a) cylindrical specimens



(b) prismatic specimens

Fig. 2: Gypsum reinforced specimens after their failure during compression test.

(a) cylindrical specimens

(b) prismatic specimens

Fig. 3: Cross-section of tested gypsum reinforced specimens after their failure during compression test.

spatial variation of the material properties is not an obstacle, since mainly the ductility of the material matters. The use of recycled material helps to solve the problem with its disposal, and even promotes the cheap brittle materials such as recycled cement-based composites or gypsum.

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