FIBRE REINFORCED COMPOSITES WITH RECYCLED BRICK & CONCRETE RUBBLE

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Abstract

The article presents findings from a study and analysis of the results of an experimental programme focused on the production of concrete and fibre reinforced concrete in which natural aggregates have been substituted with brick or concrete rubble (recyclate). By adding polymer fibres to concrete mixes fibre reinforced concrete is produced – a tough composite offering by its properties a new application potential in structures.

Keywords: fibres, composite, construction and demolition waste, concrete, recyclate, rubble

1. Introduction

One of the friendliest ways of managing the volumes of piling up waste which does not impose a very high burden on the environment is the exploitation of recycled and recyclable materials (Fig.1).

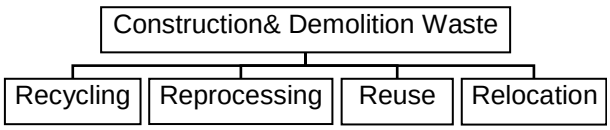

Fig. 1 The four scenarios for materials use in the built environment

In its wider context, recycling represents new material utilization for a different purpose and a system than the one in which it had originated and for which it is no longer usable. The scope of potential reuse of raw materials into new products is very wide and we may say that having mastered the waste processing technology, up to a 100% return rate of used material into new production may theoretically be achieved.

The goal of the presented article is to sum up the findings and results of experimental research focused on monitoring the properties of cement composites with significant proportions of recycled aggregates. The research included the verification of achievable characteristics of a composite in which natural aggregates had been replaced with brick or concrete recyclate. The obtained results were subsequently compared with the results presented by other research workplaces. The analysis was to verify the effect of individual components on the characteristics of resulting concrete.

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2. Masonry and concrete rubble

Recycling of construction and demolition waste is a relatively simple process which is based on quality recycled sorting. Recyclate containing solely crushed concrete (at least by 90%) coming from building structures and structural members is called concrete recyclate. Very useful recyclate is obtained from demolitions of concrete roads and motorways or railway sleepers where high-quality concretes of higher strength classes had been used.

Open literature commonly recommends the application of ca 30% of recyclate as substitution for natural aggregates. Many studies have proved that with this amount the properties of concrete are maintained at an acceptable quality level, often without any significant differences against concrete with natural aggregates. It is commonly used as filler into bitumen mixes, backfills or as base material in road construction.

3. Use of recycled rubble in concrete

One of new possibilities is the exploitation of masonry recyclate in the production of structural fibre reinforced concrete [1-3]. Fibres help to strengthen the structure of concrete with masonry recyclate enhancing, above all, the tensile characteristics of the resulting fibre concrete thus extending its application potential. High demands for the composite's full structure do not apply for selected applications.

This composite may be suitable mainly for newly built road and water management earth structures with a limited appearance and occurrence of cracks (e.g. consolidation of slopes, embankments, dam crest trenches) and also for road pavement layers, layers of industrial floors and multipurpose halls, for the construction of diverse utility services, parking places, sports grounds etc. [3].

4. Experimental programme

The experimental programme dealt with the verification of selected material characteristics of the composite relevant for presumed applications. To obtain a wide scope of results, more potential alternative versions of mixes with different amounts of binder, different water/cement ratios and different types and amounts of fibres were produced to assess achievable characteristics of the composite. The results were continuously published in [1-3 etc.]

The experiments included the production and subsequent testing of concrete in which aggregates had been fully substituted by masonry or concrete recyclates. The key parts of the fibre concrete mix are the basic components: aggregates – recyclate, cement, water and fibres. Their specific ratios and the properties of individual components principally affect the resulting behaviour of fresh fibre concrete and the characteristics of the final product.

Due to the demand for minimizing the price of the composite, the formulas were modified so that no extra admixtures or additives improving the characteristics of concretes would be necessary while preserving sufficient workability.

5. Experimental part

The experimental programme produced a wide scope of results [1-3] pointing out the achievable properties and behaviour of fibre concretes with recyclates - masonry or concrete debris.

The mix composition is based on the following principles:

- recycled aggregate of wide grading curve (a single grade, e.g. 0/32 mm),
- constant-minimum amount of binder (cement)
- weight of fibres according to the requirement of fibre concrete properties,
- amount of water according to required workability.

Recycled aggregates consisted in 100% content of natural aggregates. Unclean brick (masonry) and concrete rubble were shattered in recycling company. The advantage of the wide grading curve of the used recycled aggregate is apparent in the design of fibre concrete (the best was 0/32 mm). The recycled aggregate graded according to this limitation can be characterized as to be of the so-call wide grading curve.

For experimental tests was used synthetic polyprophylen fibres FORTA FERRO® and BeneSteel. In order to minimize cost an optimal dosage of this polypropylene fibres was determined as 0,5 % - 1,5 % of volume content.

In a mixture proportion the amount of cement was given on minimum for structural concrete according to Code EN 206-1 (260 kg/m^3). The amount of water should be decided according to workability requirements.

In the following table 1 are show the selected results of extensive experiments. Basic mechanical-physical properties as initial bulk densities, compressive strengths, flexural strengths and tensile-splitting strengths, pseudo-working diagram force – deflection, modulus of elasticity are determined.

Tab. 1 Summary of the fundamental mechanical-physical characteristics of the fibre reinforced concrete

Characteristics		Concrete rubble	Brick rubble
Bulk density	[kg/m^3]	2000-2200	1800-2100
Compressive strength	[MPa]	12-30	12-28
Tensile-splitting strength	[MPa]	1,6-2,5	1,5-3,3
Flexural strength	[MPa]	1,6-2,5	1,5-2,8
Modulus of elasticity	[GPa]	13-18	11-15

The basic mechanical behaviour in tension of the tested fibre reinforced concrete with masonry rubble is show in Fig. 2.

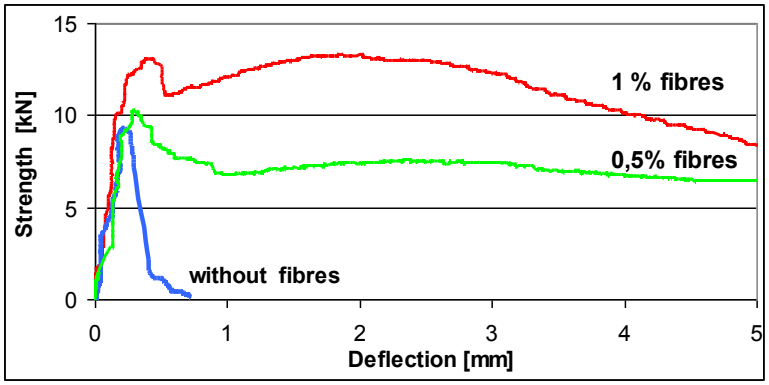

Fig. 2 Stress-strain diagram of specimens with 0%, 0,5% and 1% vol. fibres FORTA FERRO and masonry rubble (average value from 3 samples)

6. Conclusions

Based on a large series of acquired experimental results on different characteristics of the tested material, it can be judged on the behaviour of this composite. The completed experimental programme contributes to extending knowledge in using recyclates for the production of concrete and for setting the limits of achievable properties. The previous experimental program has proved that the properties of this concrete are sufficient enough to be used in ground structures as intended. With depleting natural resources new possibilities must be sought for the substitution of natural aggregates, where, thanks to its properties, brick or concrete recyclate represents a suitable alternative solution.

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7. References

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