On the Mechanical Recycling of Decommisioned Insulation Polymer Composite Components

Downloaded from: https://research.chalmers.se, 2026-11-16 10:51 UTC

Citation for the original published paper (version of record):

Grammatikos, S., Tsampas, S., Papatzani, S. et al (2020). On the Mechanical Recycling of Decommisioned Insulation Polymer Composite Components. IOP Conference Series: Materials Science and Engineering, 842(1). http://dx.doi.org/10.1088/1757-899X/842/1/012002

N.B. When citing this work, cite the original published paper.

research.chalmers.se offers the possibility of retrieving research publications produced at Chalmers University of Technology. It covers all kind of research output: articles, dissertations, conference papers, reports etc. since 2004. research.chalmers.se is administrated and maintained by Chalmers Library

(article starts on next page)

IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

On the Mechanical Recycling of Decommisioned Insulation Polymer Composite Components

To cite this article: Sotirios Grammatikos *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **842** 012002

View the article online for updates and enhancements.

IOP Conf. Series: Materials Science and Engineering **842** (2020) 012002 doi:10.1088/1757-899X/842/1/012002

On the Mechanical Recycling of Decommisioned Insulation Polymer Composite Components

Sotirios Grammatikos[1,a)], Spyros Tsampas[2,b)], Styliani Papatzani[3,4,c)], Tang Luping[5,d)], Ingemar Löfgren[6,e)], Jocke Petterson[7,f)]

[1]Group of Sustainable Composites, Department of Manufacturing and Civil Engineering, Norwegian University of Science and Technology, Gjøvik, Norway
[2]R&T Centre, GKN Aerospace Engine Systems, Sweden
[3]Hellenic Army Academy, Department of Mathematics and Engineering Sciences, Vari, Greece
[4]Hellenic Ministry of Culture, Directorate of Restoration of Medieval & Post-medieval Monuments, Athens, Greece
[5]Department of Architecture and Civil Engineering, Chalmers University of Technology, Sweden
[6]Thomas Concrete Group AB, Sweden
[7]Material Technologies, Swerea SICOMP AB, Sweden

[a] sotirios.grammatikos@ntnu.no

Abstract. Fibre reinforced polymer composites (FRPs) are being increasingly used in aerospace and automotive applications due to their high specific mechanical properties. The construction industry has also started taking advantage of the potential of FRPs for both structural and non-structural purposes. The result of this remarkable absorption of FRPs within the worldwide production market, has led to an immense increase of decommissioned thermoset-matrix components. Nowadays, the majority of the decommissioned FRP components are recovered energy-wise through incineration or simply discarded in landfills around the globe. Within the framework of this paper, we present a solution for the extension of the service life of decommissioned FRP components. Decommissioned electrical insulation FRP pipes were granulated and incorporated as fillers within both cementitious and polymer matrix composites. The effect of FRP granulates on the mechanical performance of cementitious and polymer matrix composites is examined to determine the maximum granulate-filler fraction that can be recycled without compromising the mechanical performance and manufacturing process.

1. Introduction

The majority of fibre-reinforced composites used in industries such as aeronautics, energy and transportation once they reach their out-of-service life, end up in landfill or are being used for energy production mainly via incineration (according to The Incineration of Waste Directive, 2000/76/EC) [1]. In particular, every year in Europe more than 60 000 tonnes of composite waste is produced of which most ends up in landfill around Europe or other non-EU countries (EC Waste shipment regulations (259/93/EEC)) [2].

Although incineration and disposal to landfill are very detrimental for the environment, the low cost of glass fibres and lack of commercially viable industrial recycling methods make these solutions

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

inevitable. Recently, the use of commercially manufactured fibre-reinforced composites in concrete materials has been studied by a number of researchers as a reinforcement phase in concrete [3-6]. In particular, these studies have considered fibre-reinforced composites ground into powder or reinforcing bars (rebar) cut into aggregate-sized pieces as filler/reinforcement for concrete with promising results in terms of processability and mechanical properties.
On the contrary, this work presents an investigation towards a more sustainable recycling solution for fibre-reinforced composites particularly those used in the energy industry. That said, a feasibility study to assess the potential of recycling/reuse of glass fibre-reinforced polymer (GFRP) composite insulators and discarded glass reinforcements was carried out. The concept-idea was to incorporate decommissioned epoxy-based glass fibre-reinforced insulators as fillers in i) cement-based products for potential replacement of gravel/crushed stones and ii) polymer-based products for potential replacement of reinforcing fillers i.e. glass fibre reinforcement. After a thorough investigation which involved workability, manufacturing and mechanical testing, it was concluded that discarded FRPs can be efficiently recycled (downcycling) within cementitious and polymer matrix products at 3%v/v and 25%w.w, respectively, without compromising their original structural performance.

2. Experimental

2.1. Materials

The decommissioned electrical insulating FRP tubes used in this study were supplied by ABB Composites AB, Sweden. The configuration of the tubes is illustrated in figure 1. The studied FRP tubes consisted of epoxy resin and E-glass fibres. The tubes were fabricated using filament-winding allowing for a 70% fibre volume fraction. After shredding, FRP granules where incorporated as fillers in cementitious and polymer matrix composites. The FRP-filler modified cementitious and polymer composites were subsequently structurally evaluated using standard mechanical testing (compression, 3-point bending) to assess their performance compared to the original material (no FRP-filler addition).

Figure 1. Decommissioned FRP insulation tubes from ABB Composites AB that were ground and used as filler in cementitious and polymer matrix composites.

2.2. Testing methodology

2.2.1. Mechanical recycling – shredding. The FRP tubes were converted into fillers through shredding employing a granulator provided by RAPID Granulator, Sweden, AB. The shredded fillers were filtered through a 6 mm metallic mesh.
2.2.2. Mechanical testing. Cementitious composites (mortars) were tested under compression and 3-point bending tests to evaluate the compressive and flexural strength, respectively. Compression and flexure tests were performed according to the BS EN 1015-11:1999 standard for testing. Both reference and FRP-filler modified specimens were tested with three replicates in all cases.

3. Results and discussion

3.1. Cementitious composites (mortars)

Standard cementitious mortars (1350 g sand, 450 g cement, and 225 g water) were fabricated to study the effect of FRP fillers in mortars.

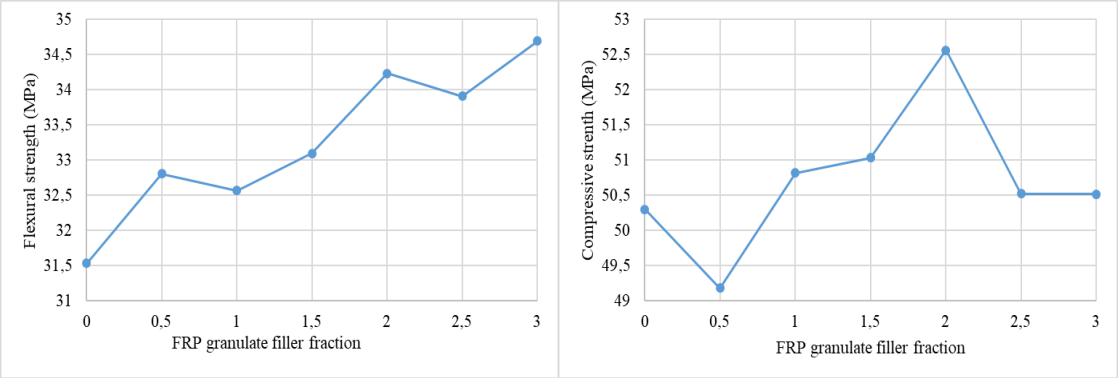

Figure 2. Flexural strength (left) and compression strength (right) for the different FRP granulate fractions.

In order to reach the goal of the study, FRP fillers were added to a certain degree or until workability of the cementitious mix was affected. To that respect, a maximum amount of 3% by volume of FRP ground fillers was added within the standard mortar mix. A gradual increase of the FRP fillers content was adopted to effectively test filler influence on the cementitious mix. Finally, prismatic mortar specimens (40x40x160mm) containing 0%, 0.5%, 1%, 1.5%, 2%, 2.5% and 3% of FRP filler were fabricated. Figure 2 depicts the mean values of flexural and compression strength for the different FRP filler fractions. As can be seen, flexural strength increases marginally with an increase in FRP fraction whereas compressive strength remains practically unaffected. However, 3%v/v was the fraction point where workability of mortars was significantly influenced.

3.2. Polymer composites

Composite laminates consisting of a mixture of ground FRP and new raw material (polymer and fibres) were produced and tested in 3-point bending testing. The laminates consisted of vinylester polymer for the matrix and E-glass glass fibres for the reinforcement together with 25%w/w recycled FRP fillers. Two types of laminates were fabricated (namely S1 and D1) using 167.89 gr (S1) and 260.59 gr (D1) of glass reinforcement, respectively. Standard wet hand-lay-up at room temperature conditions was employed for the manufacturing. Three-point bending tests were conducted in accordance with the ASTM D7264 having a support span of 150 mm. The dimensions of the test samples were 180x25 mm. Figure 3 displays the 3-point bending testing setup whereas figure 4 representative load deflection curves for the two fabricated types of specimens.

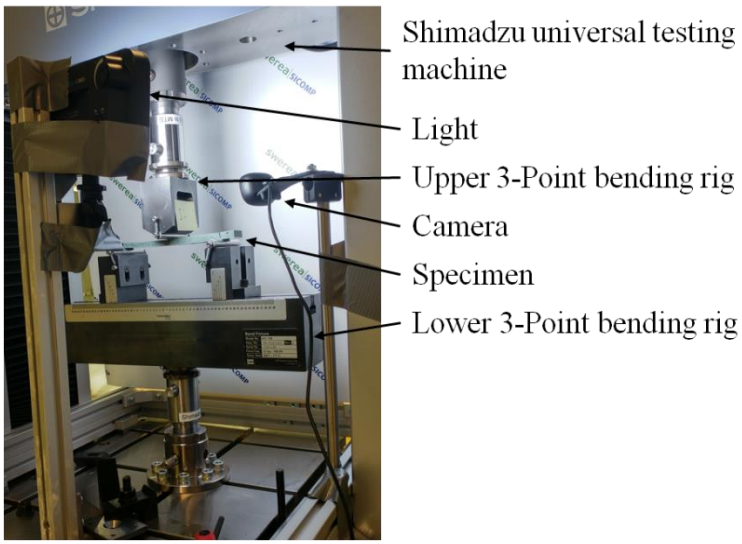

Figure 3. Three-point bending setup.

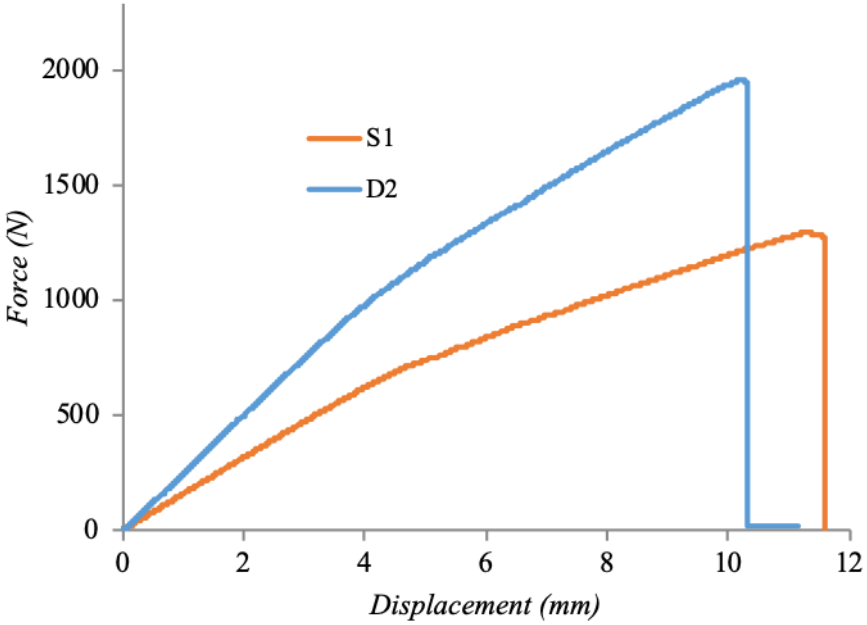

Figure 4. Load/Deflection curve from specimen S1 and D2.

4. Conclusions

In this study, it was demonstrated that FRP composite insulators can be ground down and form functional/valuable additives for both cementitious and polymer composite products. Commercial drive for introducing this type of recycling is currently considered relatively low, as the material fractions replaced with recycled material are relatively low, thus reducing the economic impetus for introduction. However, considering the environmental effects when landfilling such FRP components and the release of toxic substances when decomposing, this work significantly contributes towards the development of measures for recycling thermosetting polymer composites. From a structural point of view, FRP granulates can be employed as efficient reinforcing fillers in cementitious and polymer composites up to 3%v/v and 25% w/w, respectively, without compromising their original mechanical

behaviour. In the case of polymer composites, mechanical performance is somewhat lower than for most laminates used commercially today but high enough for many non-structural applications. The results demonstrate simple process technology for cementitious mortars and polymer composite laminates that can be applied to a variety of construction applications such as pavements, bridge decks, wall panels, boats, etc. It becomes obvious that this feasibility study proved the potential of recycling/repurposing of retarded FRP insulation pipes contributing to the waste reduction, minimization of CO_2 emissions, efficient use of resources, etc.

5. References

[1] European Commission, Directive 2000/76/EC of the European Parliament and of the Council on the incineration of waste, 2008.
[2] European Commission, Report from the Commission to the European Parliament and the Council on the implementation of regulation (EC) no 1013/2006 on shipments of waste, 2015.
[3] N. Reynolds, M. Pharaoh, An introduction to composites recycling, in: V. Goodship (Ed.), Management Recycling and Reuse of Waste Composites, Woodhead Publishing, 2010, pp. 3–19.
[4] M. Shahria Alam, E. Slater, Billah.A. Muntasir, Green concrete made with RCA and FRP scrap aggregate: fresh and hardened properties, J. Mater. Civ. Eng. 25 (12) (2013) 1783–1794.
[5] M.C.S. Ribeiro, A.C. Meira-Castro, F.G. Silva, J. Santos, J.P. Meixedo, A. Fiúza, Reuse assessment of thermoset composite wastes as aggregate and filler replacement for concrete-polymer composite materials: a case study regarding GFRP pultrusion wastes, Resour. Conserv. Recycl. (2015).
[6] A. Yazdanbakhsh LC. Bank, C. Chen, Use of recycled FRP reinforcing bar in concrete as coarse aggregate and its impact on the mechanical properties of concrete, Construction and Building Materials 121 (2016) 278–284.

Acknowledgments

This work was funded by RECYTAL project (Vinnova/Energimyndigheten/Formas (Sweden) - RESource utlysning 2 (2016-2017), Project reference: 2017-001986). Authors are thankful to Marek Machowski (Chalmers University of Technology) and Peter Hellström (Swerea Sicomp) for their contribution to experimental testing. ABB Composites, Sweden, is greatly acknowledged for supplying discarded insulation FRP tubes whereas RAPID Granulator, Sweden, for shredding FRP tubes into fragments.