An ACI Technical Publication

SYMPOSIUM VOLUME

Sustainable Concrete with Beneficial Byproducts

SP-334

Editor:
Moncef L. Nehdi

American Concrete Institute
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Sustainable Concrete with Beneficial Byproducts

Sponsored by ACI Committee 555,
Concrete with Recycled Materials

The Concrete Convention and Exposition
October 15-19, 2017
Anaheim CA, USA

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First printing, September 2019

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Printed in the United States of America

Editorial production: Gail L. Tatum

ISBN-13: 978-1-64195-077-0

PREFACE

Sustainable Concrete with Beneficial Byproducts

To improve the eco-efficiency and sustainability of concrete, the cement and concrete industry can exploit many byproducts in applications that could, in some cases, outperform conventional materials made with traditional ingredients. This Special Publication of the American Concrete Institute Committee 555 (Concrete with Recycled Materials) is a contribution towards improving the sustainability of concrete via using recycled materials, such as scrap tire rubber and tire steel wire fiber, GFRP waste, fluff, reclaimed asphalt pavements, recycled latex paint, and recycled concrete aggregate. Advancing knowledge in this area should introduce the use of recycled materials in concrete for applications never considered before, while achieving desirable performance criteria economically, without compromising the quality and long-term performance of the concrete civil infrastructure.

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Mechanical Performance of Concrete Incorporating Slender Elements from Recycling GFRP Waste

Yuan Tian and Ardavan Yazdanbakhsh

Synopsis: Due to their unique mechanical characteristics, glass fiber reinforced polymer (GFRP) composite materials are difficult to recycle at the end of their service lives. In the present work, a specific approach of recycling GFRP waste for use in concrete is investigated. Scrap from GFRP rebar and waste from a GFRP wind turbine blade shell were processed into slender elements, referred to as "needles," with a length of 100 mm and used in concrete to replace 5% and 10% of natural coarse aggregate. The results of testing various concrete specimens revealed that the incorporation of needles with longitudinally aligned glass fibers increased the splitting tensile strength of concrete significantly. Both types of recycled needles, regardless of the source of waste and orientation of glass fibers, increased the tensile toughness of concrete significantly. In addition, it was observed that incorporating needles did not reduce concrete's slump, due to the relatively high specific surface area of the needles. The findings suggest that recycling GFRP waste into needles as concrete reinforcement may be a viable GFRP waste management strategy and deserves further research.

Keywords: Concrete, Discrete reinforcement, GFRP waste, Mechanical performance, Recycled composites

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INTRODUCTION

Concrete is one of the most widely used construction materials. However, it has several shortcomings, one of which is the labor-intensive and time-consuming preparation and placement of continuous steel reinforcement. Discrete reinforcing elements, which can be added during mixing concrete, can partially eliminate this shortcoming. Currently, fibers are the only widely researched and commercialized type of discrete reinforcing elements. Fibers increase the post-failure toughness of hardened concrete, but significantly reduce the workability of fresh concrete due to their high specific surface area. Chemical admixtures that cause additional cost and environmental impacts are required to improve the workability of fresh fiber-incorporated concrete. Moreover, when used beyond limited dosages, fibers tend to agglomerate, resulting in poor reinforcement and formation of weak zones in concrete. For this reason, the dosages of fibers used in concrete are typically limited to about 0.5% of concrete volume.

The present work discusses a different type of discrete reinforcing element with low specific surface area. These elements, hereafter referred to as "needles," are rod-shape, slender and stiff. The needles studied in the present work are produced by cutting the end-of-life waste of glass fiber reinforced polymer (GFRP) composite materials. The mechanism by which needles function in concrete as reinforcement is fundamentally different from that of commercially used fibers [1-2]. Needles have relatively low aspect ratios, large diameters and, as mentioned earlier, low specific surface areas. Therefore, they do not tend to agglomerate or reduce the workability of concrete. In addition, because needles can be produced from GFRP waste, their use can be environmentally beneficial. Despite the rapid growth in the use of GFRP materials, landfilling and incineration are the primary methods for managing GFRP [3]. Processing the GFRP waste into discrete reinforcing elements for use in concrete is a potential approach to mitigate the environmental burdens of managing GFRP waste.

Several studies have been conducted on the use of GFRP waste in concrete, to extend the use phase of GFRP composite materials. The scope of those studies can be divided into two categories; using pulverized or shredded GFRP waste to partially replace fine aggregate, and using the cut pieces of the waste to partially replace coarse aggregate in concrete. Tittarelli and Correia explored the possibility of replacing fine aggregate in mortar and concrete with powdered GFRP [4-5]. The test results revealed that using GFRP powder has negative impacts on the mechanical properties of both concrete and mortar. Shahria Alam reported reduction in compressive strength and flexural strength of concrete when flat square pieces of GFRP scraps from waterslides were used as a partial replacement of coarse aggregate [6]. Yazdanbakhsh et al. found that the full and partial replacement of coarse aggregate with aggregate-shape cut pieces of GFRP rebar scrap has a