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Guide to Accelerated Conditioning Protocols for Durability Assessment of Internal and External Fiber-Reinforced Polymer (FRP) Reinforcement

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Fiber-reinforced polymer (FRP) composites, when designed, fabricated, and installed, provide a sustainable and durable reinforcement system for concrete. This document presents guidance for assessing the durability performance of internal and external FRP composite reinforcement using accelerated conditioning protocols (ACPs) in combination with standard test methods for mechanical properties. The objective of ACPs is to enable manufacturers to characterize the durability of their FRP composite products and encourage researchers and testing laboratories to adopt common test protocols to build a meaningful database of durability testing of FRP materials. Results of the tests conducted using the recommended ACPs are not intended to be used in the design of FRP composites as concrete reinforcement. In the future, however, when the relationship between field performance and ACPs is better understood, ACPs may be refined to allow use in quality control and design.

Keywords: accelerated conditioning; bond; durability; externally bonded; fiber-reinforced polymer composites; modulus of elasticity.

CONTENTS

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

This document is a guide to the assessment of the durability performance of internal and external fiber-reinforced polymer (FRP) composite reinforcement using accelerated conditioning protocols (ACPs) in combination with standard test methods for mechanical properties. The purpose of this guide is to document ACPs so that a standardized method can be created to gather data to eventually be used as a screening or acceptance tool.

FRP composites are increasingly being used in infrastructure applications as reinforcing bars and externally bonded reinforcement for strengthening reinforced concrete elements. The use of FRP composites is predicated on performance attributes linked to their light weight, high stiffness-to-weight and strength-to-weight ratios, ease of installation in the field, potential low system cost, and potentially high overall durability.

FRP composites are used by many industries, including automotive, marine, and aerospace. They have successfully been applied in pipelines, underground storage tanks, building façades, and as architectural components. The materials, loading conditions, and environments seen in many infrastructure applications, however, are unique. Anecdotal evidence provides substantial reason to believe that, if appropriately designed and fabricated, FRP composites can provide longer service life and lower maintenance costs than steel-reinforced structures.

FRP composites have been in use as concrete reinforcement since the 1980s. Consequently, long-term performance field data are limited, making it essential that potential vulnerabilities regarding FRP durability be identified and addressed early to ensure expected long-term service. One means to identify long-term vulnerability is through the use of accelerated conditioning. Few standard protocols for conducting durability testing exist, making it difficult to draw detailed conclusions from the present database of test results generated over the past two decades. Comparing tests conducted at different laboratories is often complicated by the large number of variables among tests.

FRP composite reinforcement embedded in concrete will experience different environmental influences than those experienced by externally bonded FRP composite reinforcement. Externally bonded FRP composite reinforcement is typically exposed directly to ambient environmental conditions where embedded reinforcement is not. In many applications, the bond of externally bonded FRP composite reinforcement is critical to the short- and long-term structural performance of the system. Due to the fundamental difference in exposure conditions of internal and external FRP composite reinforcement, different ACPs and mechanical testing for internal and external FRP composite reinforcement are necessary. In either case, durability, in the context of this guide, is defined as a measure of the retention of FRP physical and mechanical properties when exposed to the ACP environments for the prescribed duration.

An overview of the evaluation process includes the following four elements:

1) Specimen fabrication and preparation—Process used to fabricate the specimen and prepare it for exposure to the ACP.

2) Accelerated conditioning protocol—Sets out the parameters for the environment and stress, including duration, to which the specimen will be exposed (Chapter 4). Additional control specimens are stored in ambient laboratory conditions.

3) Mechanical testing—Tests the accelerated conditioned (AC) and control specimens following the exposure period. Testing is completed under unexposed conditions (Chapters 5 and 6).

4) Residual mechanical property determination—The method used to evaluate the effect of ACP on mechanical properties (Chapters 5 and 6).

1.2—Scope

This document provides guidance on using ACPs and associated standard mechanical test methods to assess the durability of FRP composite reinforcement for concrete with the objective to enable manufacturers to characterize the durability of their FRP products and to encourage researchers and testing laboratories to adopt common test protocols to build a meaningful database of durability test results for FRP materials. Results of the tests conducted using the recommended protocols are not intended for use directly in the design of FRP composites. They are meant to generate a database of consistent test results that can be