Glass Fibre Reinforcement - Durability and Structural Design

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Abstract: Reinforced concrete is a composite material with tensile strength enhanced by reinforcement. An avoidance strategy for the corrosion to reinforcement induced by chloride attack and carbonation, is the use of glass fibre reinforcement. This material is achieving rapid take-up in Australia in maritime facilities. A desktop risk assessment suggests the durability of GFRP material is influenced by chemical and thermal deterioration mechanisms of the epoxy or vinyl ester binder indicating the need for quality assured polymers meeting Tg ≥ 100 °C. The properties of several different bar types now available in Australia are illustrated indicating a unique design required on a product-by-product basis. Some key features of the differences between carbon steel reinforcement design and GFRP bar design are explained with reference to the available international standards. Work constructed and in progress designed by ATC include jetties, wharves, dolphins, crash barriers, precast walls, slab on grade and balconies in marine exposure zones.

Keywords: Fibre reinforced polymer (FRP), Glass FRP (GFRP), reinforcement, durability, marine, corrosion, concrete, structural design.

1. Introduction

1.1. Challenges to Durability of Marine Environs

The Concrete Institute's treatise on performance concretes for marine environs states "In Australia, steel corrosion is considered to be the main cause of deterioration of reinforced concrete exposed to marine conditions" (1). Structural strategies for durability include design of the shape of the member for the additional impacts and cracking that may ensue due to events during service, in addition to limiting original cracks with potential to admit sea water (4).

To increase design lives in B1-C2 marine exposure zones from 25 years to 50-100 years, material durability strategies may include: increasing the cover of the concrete (4-7); reducing the porosity of the concrete by increasing the grade (4-7); reducing porosity and increasing water repellency by use of admixtures; specification of mix designs of performance concretes (1, 6, 7); in addition to crack (width) control by design and admixture.

Performance concretes limit the shrinkage, capillary suction and diffusion of seawater into concrete and generally offer improved matrix chloride and sulfate resistance (1, 6, 7) as measured by durability tests (refs 1,3,6,7) that are not specified in AS 3600 (5). Crack control by design, admixture and repair is necessary[1]. Durability proposals may include cathodic prevention solutions such as impressed current protection introduced into the new build (12). Planning for future maintenance includes concrete repair, sacrificial anodes and/or cathodic protection (12). Other post-construction strategies include barriers such as coatings and impregnations, pile jackets (12). The costs of these strategies are variable and add to the base price of concrete estimated in Table 1 overleaf.

Fibre Reinforced Polymer (FRP) reinforcing bars and strands are made from filaments or fibres of glass held in a polymeric resin matrix binder (or glue), epoxy or vinyl ester by a process known as pultrusion. The focus of this article is glass FRP (GFRP) for structural concrete. Such composites are electrical, thermal and magnetic insulators, and do not corrode in the same manner as steel in chloride-contaminated or carbonated concrete and can offer an alternative to steel reinforcement known as an "avoidance" strategy.

[1] Crack repair is not necessarily recommended during defects liability due to movement at this phase.