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Durability of FRP Immersed in Water. Changes in Mechanical Properties

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1 Introduction

Fibre Reinforced Polymers have been commonly used to strengthen existing building structures in the last years. However, FRP durability have been a controversial topic. Some researchers investigated the durability of FRP components. In this line, carbon fiber has been proved to be resistant to acid and alkali environments (Zhu & Hu, 2017). In contrast, glass fiber is known to degrade in presence of water, especially in alkaline environments (Bank, Gentry, & Barkatt, 1995). According to (Department of Defense USA, 2002) epoxy shows good chemical resistance but its mechanical properties are clearly reduced in the presence of moisture (Panda & Mamta, 2010). Polyester durability mostly depend on their typology. Hence, orthophthalic polyester is far more affected by water presence than isophthalic polyester. Regarding the durability of FRPs, it is stated (Cromwell, Harries, & Shahrooz, 2011; Karbhari et al., 2003) that hydrothermal effects are dominant. Beside moisture, chemical attack (e.g. acid and alkali solutions) also contributes to degradation of FRP by accelerating the hydrolysis process (Karbhari et al., 2003). Studying the particular effects of salts and surfactants rich water and highly chlorinated water is necessary for the application of these materials on water treatment plants.

2 Materials and Methods

Two types of FRPs were produced and tested: glass fiber and polyester resin FRP (GFRP) and carbon fiber and epoxy resin FRP (CFRP). Tensile tests were performed on unaltered samples, samples immersed in supply water, samples immersed in water with salts and surfactants representing increased aggressivity waste water and water highly chlorinated to represent a long term effect of chloride in supply water. All immersed specimens were subjected to an imposed current during the two weeks immersion lasted. Tensile testing was carried out at 2mm/min. ATR FTIR analysis was also performed.

3 Results and Discussion

Average results of tensile strength (f_t) and elastic modulus are presented Table 1. It may be stated that chlorinated water caused the reduction of tensile strength and elastic modulus for both FRPs. Wastewater causes the reduction of mechanical properties of GFRP but increases the ones of CFRP. Finally, exposure to supply water reduces the tensile strength but increase the elastic modulus. Results of the ATR-FTIR analysis showed that no hydrolysis happened because hypothetically resulting hydroxyl group was not detected in any case.

Table 1. Results of the tensile tests.

	Supply water		***Wastewater***		***Chlorinated water***		***Untreated***	
	f_t *(MPa)*	*E* *(MPa)*	f_t *(MPa)*	*E* *(MPa)*	f_t *(MPa)*	*E* *(MPa)*	f_t *(MPa)*	*E* *(MPa)*
CFRP	1026	31434	1318	31110	1199	26296	1280	27525
GFRP	148.6	3647	139.6	3238	148.2	3443	157.2	3481

4 Conclusions

Water adsorption by the resin matrixes causes the swelling of the polymer. This leads to a reduction of the tensile strength, although the presence of massive ions on sample surface reduced this adsorption. In addition, glass fiber is degraded by moisture adsorption and by alkaline media, whereas carbon fiber is stable.

As practical conclusion, plain water is showed to be the most aggressive media for the matrix resin and a real problem to be faced for improving FRPs durability.

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