

Lesson Plan: Statistical Analysis of CFRP/Concrete Bond Strength Data

Course: Advanced Placement Chemistry and/or Honors Research I

Author: Laura Lanni (July 2003)

Introduction: During the 2003 summer RET at USC, polymers (natural and synthetic) and concrete chemistry were investigated. The purpose of the research was to investigate the influence of recycled crumb rubber in a carbon fiber-reinforced polymer (CFRP) matrix. The CFRP was wrapped around concrete columns as reinforcement to improve compressibility. Adding crumb rubber was intended to improve impact resistance. However, the strength of the CFRP/concrete bond was also tested. This lesson will involve analysis of the actual bond strength data to answer the question: “How does addition of recycled crumb-rubber to the epoxy polymer influence the bond strength of the CFRP to concrete?”

Background: Two types of crumb rubber were used. They were GF80 and GF170, and were different from each other based on their size of particles. The GF80 had a larger size. Each crumb rubber was added at a 10% level to the epoxy/amine polymer during mixing. The CFRP with and without the crumb rubber were applied to concrete bricks. Some of the bricks were impacted with a 6kg, one square-inch drop striker that was dropped from 20 feet. Others were not impacted. The bond strength at the impact (or no-impact) site was tested with a pull off tester. The data from these tests are below.

Problems: Analyze the following data to answer the question: How does addition of recycled crumb-rubber to the epoxy polymer influence the bond strength of the CFRP to concrete?

no impact			6kg impact		
Sample name	Rubber additive?	Bond strength N/mm ²	Sample name	Rubber additive?	Bond strength N/mm ²
616A0	no	5.32	616A3	no	3.71
618A	no	5.44	618A	no	3.1
			630A1	no	4.86
616B0	10%GF80	5.03	630A2	no	4.49
618B1	10%GF80	4.82	630A3	no	4.41
			630A4	no	4.24
616C0	10%GF170	5.08			
618C1	10%GF170	6.00	616B3	10%GF80	5.03
			630B2	10%GF80	5.36
			630B3	10%GF80	5.39
			630B4	10%GF80	3.90
			616C3	10%GF170	4.36
			630C1	10%GF170	3.66
			630C2	10%GF170	5.77
			630C3	10%GF170	5.38

Lesson Organization:

A short (10 minute) whole-class discussion on statistical analysis will cover ideas of averages, standard deviations, graphical representation of results, and error bars. Students will work in groups of 3 or 4 to analyze the data. They will be allowed use of computer graphical analysis, Excel, and their graphing calculators for this work, and will be given 30-40 minutes. After analysis is completed, the whole class will compare results and make conclusions.